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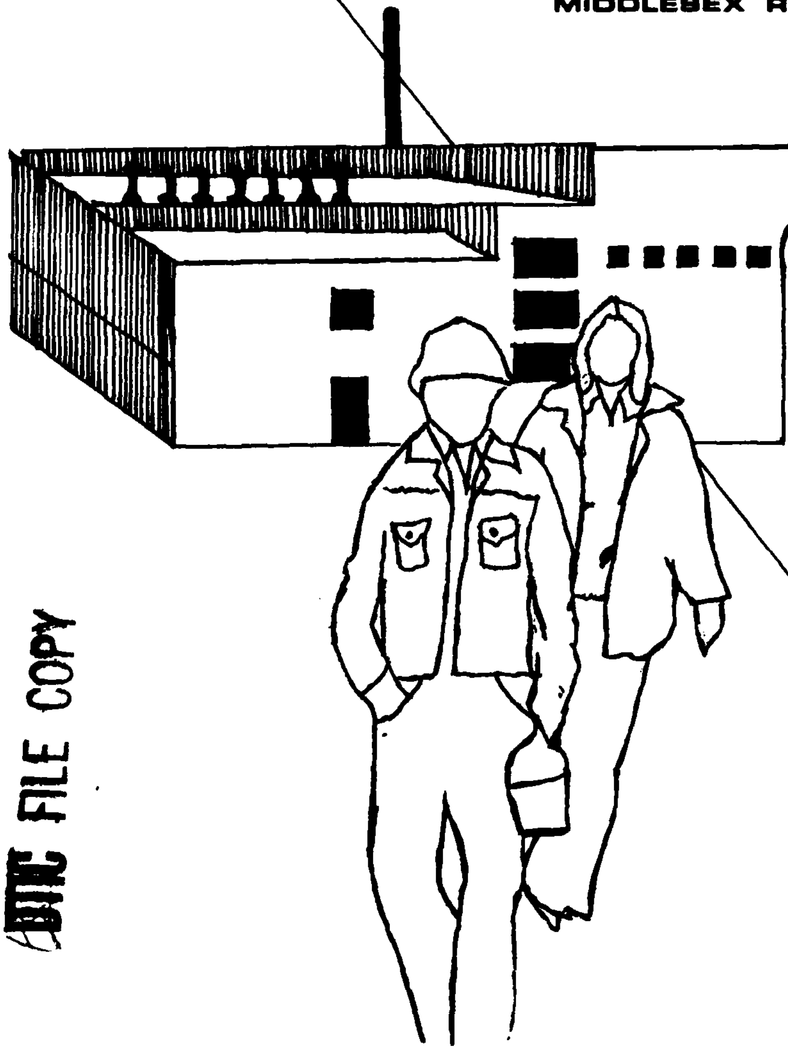
# EFFECTS OF METRIC CHANGE ON WORKERS' TOOLS AND TRAINING

PREPARED BY

MIDDLESEX RESEARCH CENTER, INC.



FOR



UNITED STATES METRIC BOARD



JULY 1981

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>None | 2. GOVT ACCESSION NO.<br>AD A107595 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>Effects of Metric Change on Workers' Tools and Training | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final |
| | | 6. PERFORMING ORG. REPORT NUMBER<br>None |
| 7. AUTHOR(s)<br>Not applicable | | 8. CONTRACT OR GRANT NUMBER(s)<br>AA-80-SAC-X8605 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Middlesex Research Center, Inc.<br>3413½ M Street, NW<br>Washington, DC 20007 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>None |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Office of Research; Office of Research, Coordination & Planning; U.S. Metric Board, 1600 Wilson Blvd., Suite 400, Arlington, VA 22209 | | 12. REPORT DATE<br>July 1981 |
| | | 13. NUMBER OF PAGES<br>142 |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)<br>Same | | 15. SECURITY CLASS. (of this report)<br>Unclassified |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE<br>Not applicable |

16. DISTRIBUTION STATEMENT (of this Report)

Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Unlimited

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Metrication, occupations, measurement sensitive, tax credits, unions, elderly workers

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of the study was to gain an understanding of the effects of metric change on selected occupations. The study focuses on four areas: tool, training, career, and companion (i.e., safety, productivity and collective bargaining) issues. The occupations studied form a typical but non-probability sample and were chosen for their metric sensitivity. The industries for the occupations are machinery, construction, packaging, transportation, electrical, and automotive services. (cont.)

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20 (cont)

The study was developed with the assistance of an advisory panel, consisting of representatives from business, labor and academia. The study methods included background research, telephone and face-to-face interviews, and data analysis. Findings and conclusions are presented for each of the issues mentioned above.

# EFFECTS OF METRIC CHANGE ON WORKERS' TOOLS & TRAINING

FINAL REPORT

Prepared by

MIDDLESEX RESEARCH CENTER, INC.

Prepared for

THE UNITED STATES METRIC BOARD

Contract Number AA-80-8605

July 15, 1981

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## SUMMARY

### INTRODUCTION

With the passage of the Metric Conversion Act of 1975 (P.L. 94-168), the U.S. Congress established a national policy of planning and coordinating the increasing voluntary use of the metric system. It also established the U.S. Metric Board to plan and coordinate voluntary conversions to the metric system.

The U.S. Metric Board has been directed by Congressional mandate to conduct research; publish the results of such research; and recommend to the Congress and the President such action as may be appropriate with regard to unresolved problems, issues, and questions relating to metric conversion in the United States. This study, "The Effects of Metric Change on Worker Tools & Training", is one of the research efforts undertaken in response to this mandate.

### BACKGROUND

The purpose of this study was to gain an understanding of the effects of metric change on selected occupations. The study focuses on metric change in four areas: tool issues, training issues, career issues, and specified companion issues. The companion issues -- safety, productivity, and collective bargaining -- were investigated as a preliminary task prior to possible further research by the USMB.

The occupational areas studied formed a typical but non-probabilistic sample and were chosen for their metric sensitivity. These areas are the machinery, construction, packaging, transportation, electrical, and automotive service industries.

The study methodology was developed with the assistance of an Advisory Panel; the panel members were chosen for their backgrounds and expertise in business, labor and academia. The study methodology included background research, telephone and on-site interviews, and analysis of the data by the study team. In selecting the organizations for the on-site interviews, the study team used the criteria of active metric measurement use, cooperativeness of management and labor, and location.

### FINDINGS AND CONCLUSIONS

This research effort has revealed several important points that are useful in determining the impact of metrication on worker tools and training. However, because a non-probabilistic sample was used, inferences regarding the entire United States workforce should be made carefully.

## Tool Issues

In researching tool issues, the study team discovered that tool costs vary considerably. The costs of purchasing metric tools ranges from $100 to nearly $1000, and the cost is generally higher for tool and die makers and workers in the vehicle service occupations than it is for production or manufacturing industry workers. Generally speaking, metric tool costs are met by the employer, not the worker. However, in some industries -- particuarly the vehicle service industry -- certain workers must purchase all of their own tools. This can result in a substantial outlay of money by the individual worker; for example, a complete set of metric tools required for automotive work can run as high as $800. Accordingly, the individual worker who must purchase his own tools will frequently acquire various tools over a period of time rather than buying a complete set all at once. The study team also found that many workers do not take advantage of the opportunity to deduct tool expenses from their taxes as itemized business-related expenses. Thus, in certain occupations, the cost of purchasing metric tools can be relatively expensive; but for some individuals, it is an unavoidable cost if they wish to remain competitive in their job market.

## Training Issues

The cost of metric training also varies considerably, depending on whether existing training programs are available, what materials are used, and the time involved in conducting a training program. The cost per employee ranges from $15 to $350, with the greatest element of expense being the wages that are paid to workers if they are attending the program on company time. The results of the research indicate that the employer usually pays for metric training; however, in one union shop, the employees were trained on their own time with materials supplied by the union. In two plants operated by German firms, employees must attend technical training classes that include metric topics at a local technical college as a prerequisite to employment. Further, the workers in some industries receive no formal metric training at all. The number of hours involved in metric training programs ranges from two to 20 hours per employee, depending on the requirements of the individual worker's occupation.

Several other factors relating to training issues were also researched by the study team. Many of the workers who were interviewed noted that they had experienced anxiety about having to learn and use the metric system. However, this anxiety generally seems to have been dispelled by the training programs, and the workers indicated that they had adapted well to using the metric system in their jobs. Another problem that the team uncovered is a considerable amount of duplication of metric training materials, caused by a lack of information regarding sources of such materials. Training materials have been developed by both in-house corporate trainers and outside consultants; and, in some cases, workers were required to obtain their metric "education" from local technical schools or colleges. Accordingly, there appears to be a need for a mechanism to communicate the availability of the various existing metric training programs.

## Career Issues

The study team's investigation into the impact of metric conversion on career issues revealed that there is little, if any, effect on career paths and job mobility at the present time. Once training has been provided and an understanding of the metric system has been attained, widespread usage of the metric system in an organization does not appear to have any impact on the careers in the occupations that were examined.

## Companion Issues

The U.S. Metric Board requested that some research be conducted on the issues of collective bargaining, safety, and productivity. The study team learned that although the unions are cognizant of metric issues (such as tool costs), these issues have had little impact on the collective bargaining process to date. With respect to safety issues, it appears that a lack of understanding of the metric system, and particularly a lack of fluency in converting customary measurements to metric measurements, may increase the potential for safety hazards in the performance of certain occupational job tasks. Metrication may also have an impact on the productivity of some workers. This seems to be especially true in the vehicle service occupations; many of the mechanics who were interviewed felt that, because they frequently have to use both customary and metric sized tools on a single automotive unit, their rate of productivity is reduced.

## Other Issues

Several additional issues relating to metric conversion were uncovered in the course of the Worker Tool and Training Study. Many of the organizational personnel who were interviewed during the project expressed concern about the government's lack of guidance with respect to voluntary metric conversion efforts; in their opinion, this lack of guidance adds to market uncertainty and is detrimental to a gradual, voluntary transition to the use of metric measurement in the United States. Some of the study participants also noted that it was extremely difficult to locate sources of existing metric training materials. This problem has led to a tremendous amount of duplication in the development of such materials, which in turn increases the costs involved in providing metric training programs. Finally, the study team found that the ease with which metric conversion is accomplished can be enhanced if labor is involved in the effort at the outset. Once workers became familiar with the metric system, their fear about it and opposition to it decreased dramatically.

## RECOMMENDATIONS

MRC has formulated three recommendations for the U.S. Metric Board as a result of our study on The Effects of Metric Change on Worker Tools and Training.

## Study Safety Issues

MRC's first recommendation is that the U.S. Metric Board should study the impact of metric conversion on occupational safety. Since the Worker Tool and Training Study was not intended to focus on a detailed analysis of safety issues, MRC did not examine them in depth. However, based on information that was gathered during the on-site visits, we have concluded that there is a potential for increased safety hazards in certain job tasks. For example, a worker whose job involves lifting heavy equipment with an overhead crane may experience difficulty in safely estimating the weight of units if he is accustomed to dealing with customary weights and the markings on the units have been changed from U.S. tons to metric tons. There are a number of specific job tasks that appear to be susceptible to increased safety problems as a result of metric conversion; therefore, we believe that occupational safety is an issue that the U.S. Metric Board should examine in more detail than was possible in the Worker Tool and Training Study.

## Investigate Tax Credits for Conversion Costs

MRC also recommends that the U.S. Metric Board, in conjunction with the Treasury Department, investigate the feasibility of providing tax credits to workers who must invest substantial amounts of money in tools as a result of metric change. Many workers are unaware that they can take a tax deduction for the tools that they are required to purchase as a condition of their employment. In other cases, the worker cannot take advantage of the deduction because he is not in a tax bracket that makes it profitable for him to itemize. A tax credit could significantly lessen an individual's costs for work-related metric tools.

## Establish an Educational Clearinghouse

Finally, MRC believes that the U.S. Metric Board should establish a clearinghouse service through which sources of metric training materials can be made known to the private sector. The clearinghouse would be the initial point of contact for employers who want to obtain such training materials. The Metric Board should attempt to compile a list of the various sources of metric training materials and make the list available to interested organizations.

# I. INTRODUCTION

This report presents the results of a study of the impact of metric change on individual worker tools and worker training. The study was undertaken by Middlesex Research Center, Inc. under contract to the United States Metric Board.

## A. STUDY BACKGROUND

As a result of Public Law 94-168, known as the Metric Conversion Act of 1975, the U.S. Metric Board was authorized to undertake certain types of research regarding the effects of metric conversion. Under the leadership of its research committee, the U.S. Metric Board has determined that the impact of metric conversion on individual workers is an important area of research.

During October of 1979, the U.S. Metric Board began its initial research in the area of Worker Tools and Training[1]. This (1979-1980) study, entitled "The Effects of Metric Conversion on Measurement and Dimensional Sensitive Occupations", was conducted in two phases. Phase IA analyzed the Dictionary of Occupational Titles (DOT) to determine which occupational areas seemed to be measurement sensitive. These occupational areas were used to formulate research objectives for future studies. The results of Phase IA were used to identify the initial goals for the current (1980-1981) Phase II study of tool and training issues. Phase IB of the study is not yet completed.

## B. HISTORY OF WORKER TOOL AND TRAINING ISSUES

From the onset of metric conversion activities in the United States during 1969 and 1970, organized labor within the U.S. has expressed concern regarding metric change. This concern has generally focused on the potential cost of replacing individual tools and the potential training requirements to teach workers a new and apparently confusing measurement system. Labor's concerns have been thoroughly documented in testimony before Congress, presentations to the U.S. Metric Board, input to the General Accounting Office study, and materials submitted through the American National Metric Council (ANMC). In contrast, many other views, typically those of metric advocates who claim the tool and training impacts are trivial, have been equally well documented in the same media. However, since no definitive analysis had been conducted, factual data upon which the U.S. Metric Board could draw conclusions and take actions was not available.

The first USMB study of worker tool and training impacts was conducted in two phases. Phase I addressed a broad analysis of a stratified random sample of occupations drawn from the Dictionary of Occupational Titles produced by the Department of Labor. This analysis determined the extent to which various occupational categories appeared to be measurement sensitive,

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specification sensitive, or process sensitive.* In addition, this analysis provided some general data using the 1976 employment statistics showing where, within the Dictionary of Occupational Titles, the U.S. workforce is distributed. Thus, the analysis of this data identified the occupations where both high measurement sensitivity and large workforces exist.

## C. SCOPE OF THE STUDY

The overall purpose of the current study was to develop factual data regarding a limited number of occupational areas. This data was to focus on the impact of metric change on tool issues, training issues, and career issues. Since this basically represents a new area of research, and the Metric Board is limited in the extent of its research funds, the Board chose to narrow the scope of this study so as to provide more accurate data for a limited, but representative, number of occupations. The scope of the study was limited as follows.

- Select up to 20 occupations in which a high degree of measurement, dimensional, or process sensitivity is expected and focus the study on these occupations.
- Determine the nature and extent of the impact of metric change on a variety of training issues within those occupations.
- Determine the nature and extent of the impact that metric change will have on a variety of tool issues within those occupations.
- Determine the effect that metric change may have on career issues that may be associated with particular occupations, industries, or geographic areas within the United States.
- Establish a baseline for future in-depth studies regarding peripheral issues, such as safety and productivity.

The work accomplished during the Phase I Study provided a baseline for the current study. A summary of this set of data using 1976 employment statistics indicates the following:

| Type of Metric Impact* | Percentage of Work Force Impacted | No. of Workers Impacted |
|---|---|---|
| Measurement Sensitive | 30.5 percent | 26,706,317 |
| Specification Sensitive | 12.3 percent | 10,726,256 |
| Process Sensitive | 19.2 percent | 16,789,993 |
| Not Sensitive | 54.0 percent | 47,273,256 |

* See Section III.B for Definitions of Metric Sensitivity.

Note that the job categories are not mutually exclusive, and they may contain several types of measurement activity. The significance of these figures is that approximately one-third of the U.S. worker population, or 26,700,000 people, will actually perform some measurement activity as a part of their jobs. These measurement activities will be of many types; some will use linear measurement instruments or weighing devices, and others will measure volume, pressure, etc. Exhibit A portrays the distribution of two-digit DOT occupational codes indicating an estimate of the number of workers potentially impacted by metric change. Approximately 12% of the workforce uses dimensionally sensitive products defined by specifications, while 19% perform calculations on, tabulate, or process measurement data. Exhibits B-1, B-2, and B-3 show for each major category of sensitivity (measurement, specification, and process) the estimated number of employees whose jobs are potentially impacted.

## D. STUDY OBJECTIVES

Although the broad goal of this study was to gain an understanding of the effects of metric change on selected occupations and the associated implications for tool and training issues, the study was focused by defining specific objectives. Thus, preliminary objectives were developed and reviewed with the U.S. Metric Board research staff at the beginning of the contract. The final study objectives were as follows.

### 1. Tool Issues

- Determine for a selected number of occupations what tools have to be replaced or acquired, how this will most likely be accomplished, and what the nature of the costs will be.

### 2. Training Issues

- Determine the level and nature of educational programs provided to individuals within the selected occupations.

- Determine the impact that metric change may have upon these educational programs.

- Determine the nature, cost, and delivery methods for metric training for various occupations and skill levels.

- Examine the alternative mechanisms for delivery of metric training within the selected occupations.

3. Career Issues

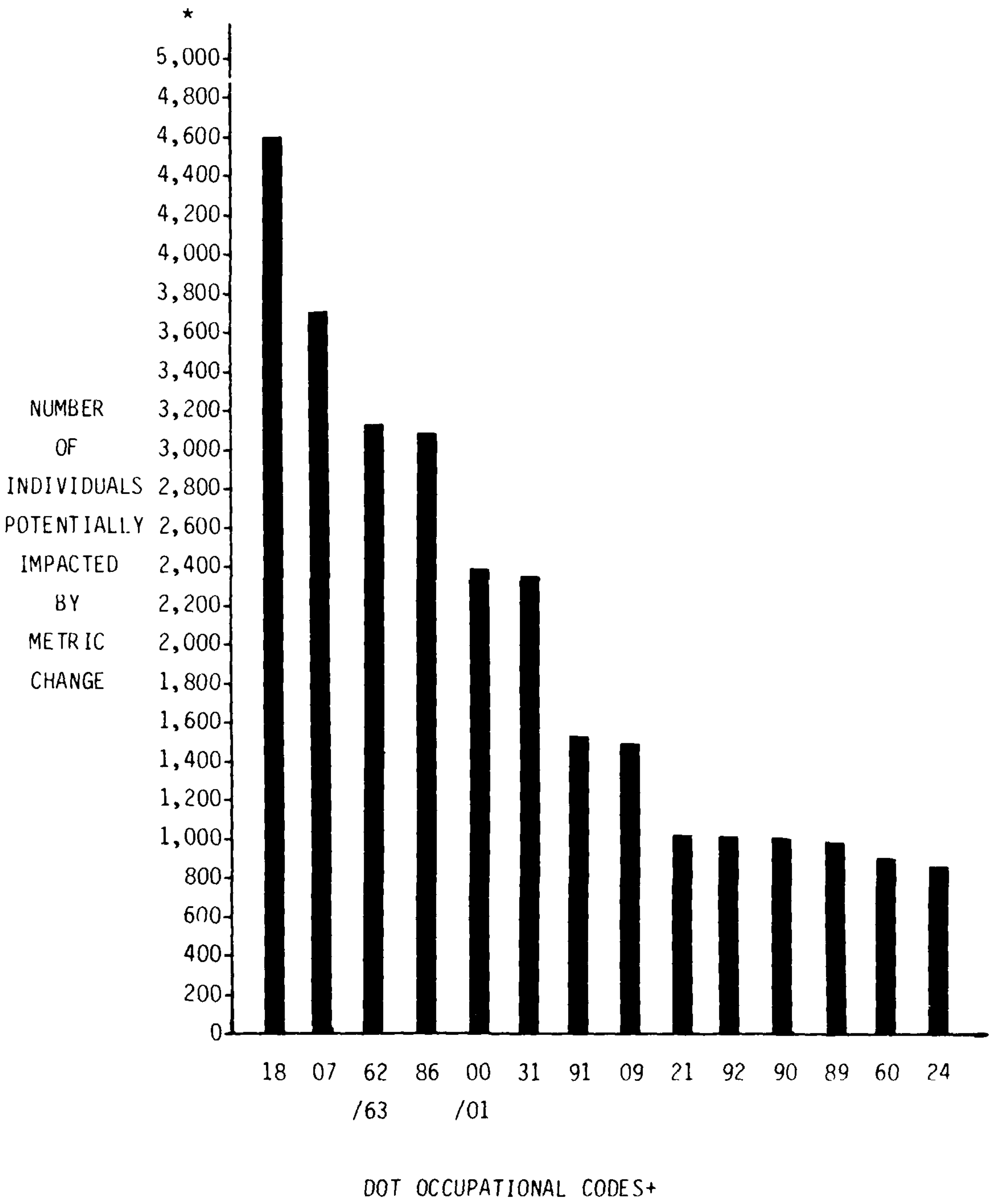
- Explore the use of career mechanisms such as job enrichment, job rotation, job enlargement, and alternative career ladders within the various occupations and analyze the impact that metric change may have on these practices.

- Determine what parameters -- such as occupation, proficiency level, industry, or employment conditions -- may influence the nature of these impacts resulting from metric change.

4. Companion Issues

- To the extent possible, determine what impact metric change will have on safety issues and productivity issues within the occupations to be analyzed. Identify within this activity the nature of future research efforts that could be pursued in these two areas.

DISTRIBUTION OF WORKERS IMPACTED BY METRIC CHANGE




* All values are in thousands based on 1976 employment figures

+ See Appendix I for DOT Code Descriptions

EXHIBIT A-1.2

DISTRIBUTION OF WORKERS IMPACTED BY METRIC CHANGE

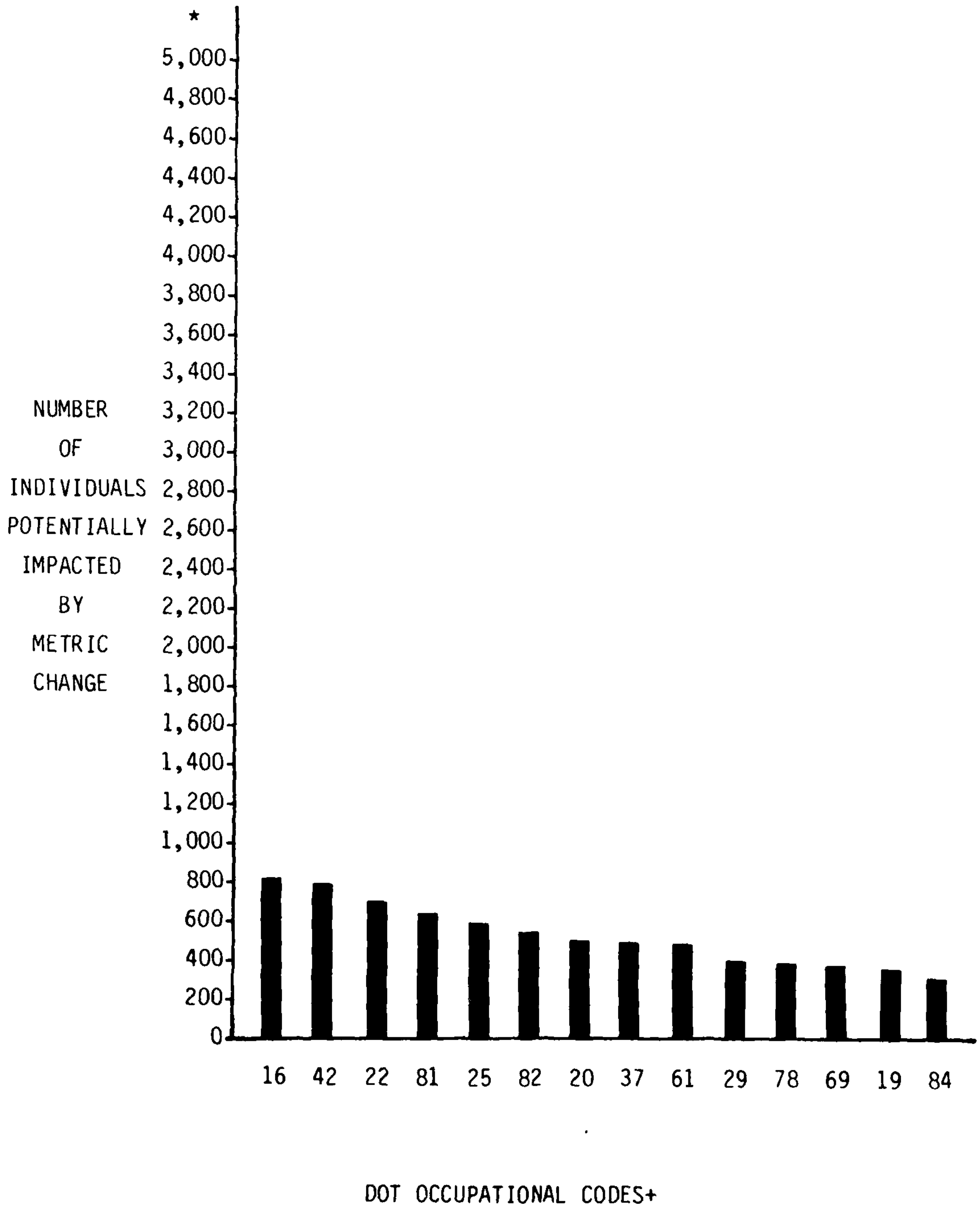



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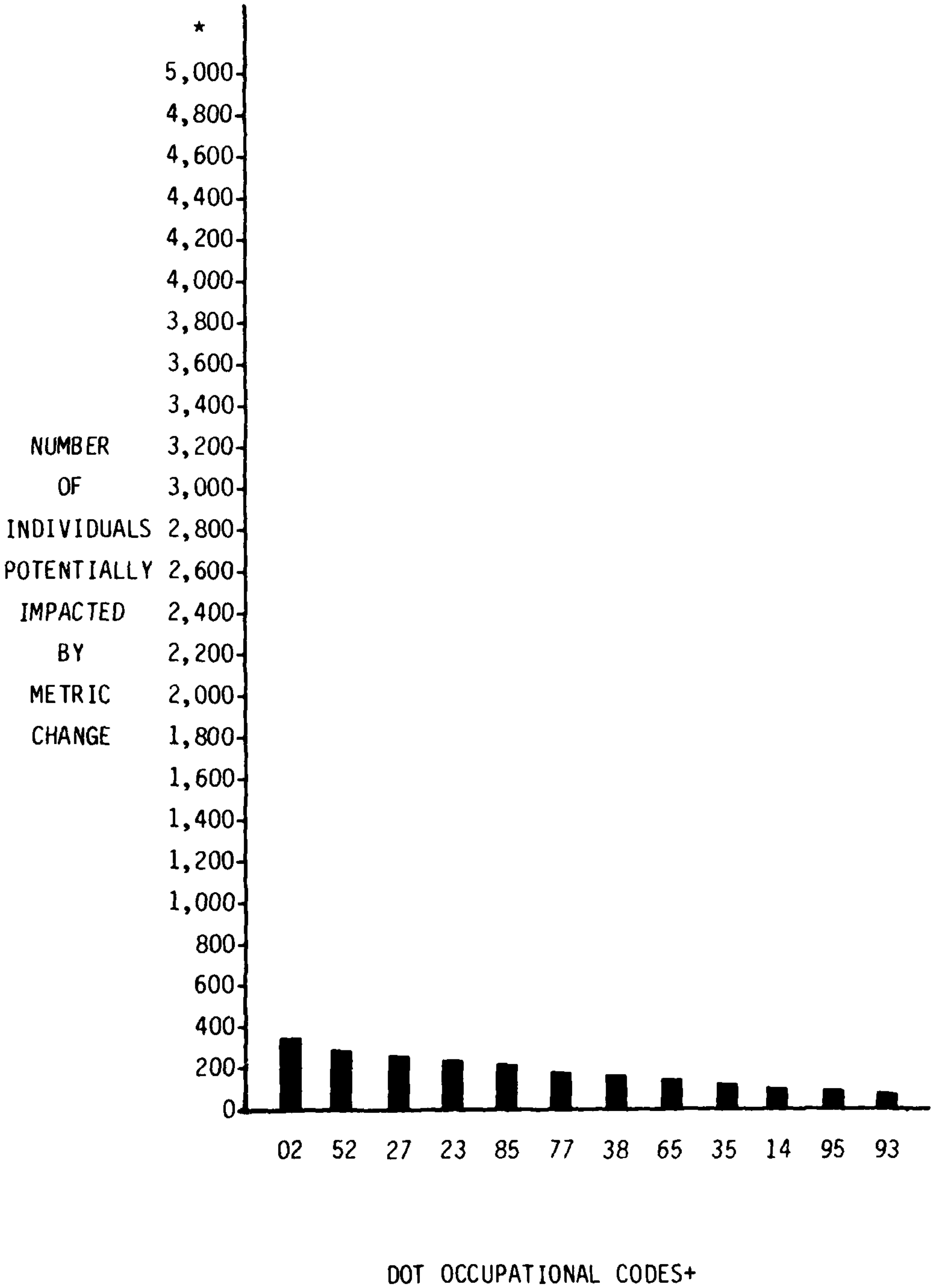
EXHIBIT A-1.3

DISTRIBUTION OF WORKERS IMPACTED BY METRIC CHANGE




* All values are in thousands based on 1976 employment figures

\+ See Appendix I for DOT Code Descriptions

EXHIBIT A-2

NUMBER OF WORKERS IMPACTED BY METRIC CHANGE

(DOT Categories with Less than 100,000 Workers Impacted)

| DOT OCCUPATIONAL CODE+ | 1976 Employment |
|---|---|
| 04 | 99,814 |
| 67 | 93,074 |
| 70 | 89,135 |
| 30 | 87,499 |
| 15 | 84,797 |
| 13 | 80,697 |
| 05 | 74,840 |
| 10 | 69,881 |
| 41 | 69,100 |
| 66 | 49,886 |
| 97 | 46,547 |
| 40 | 43,654 |
| 11 | 41,939 |
| 45 | 31,790 |
| 50 | 26,872 |
| 74 | 21,796 |
| 55 | 17,275 |
| 68 | 17,155 |
| 59 | 12,037 |
| 76 | 9,757 |
| 71 | 7,398 |
| 80 | 3,269 |
| 73 | 2,399 |
| 12 | 0* |
| 32 | 0 |
| 33 | 0 |
| 34 | 0 |
| 36 | 0 |
| 46 | 0 |

+ See Appendix I for DOT Code Descriptions

* Due to inconsistencies between the DOT codes and employment statistics, these codes appear with so few employees as to be approximately zero.

EXHIBIT B-1

Estimate of the Number of Employees Whose Jobs Are Measurement Sensitive: For Two-Digit DOT Occupational Titles With Over 500,000 Employees Impacted.

| Estimated Number of Employees Impacted | DOT Code | Occupational Title |
|---|---|---|
| 3,122,059 | 62/63 | Mechanics and Machinery Repairers |
| 3,119,065 | 86 | Construction |
| 2,859,185 | 07 | Medicine and Health |
| 2,342,781 | 00/01 | Architecture, Engineering and Surveying |
| 1,516,295 | 09 | Education |
| 1,314,206 | 18 | Managers and Officials |
| 1,010,000 | 92 | Packaging and Materials Handling |
| 957,732 | 91 | Transportation |
| 910,966 | 60 | Metal Machining |
| 908,149 | 89 | Structural Work Occupations |
| 807,092 | 42 | Agricultural and Related Occupations |
| 737,345 | 16 | Administrative Specializations |
| 590,171 | 90 | Motor Freight Occupations |
| 500,000 | 82 | Electrical Assembling, Installing, and Repair |

Source: "The Effects of Metric Conversion on Measurement and Dimensional Sensitive Occupations" Final Report - Volume I - December 1980

EXHIBIT B-2

Estimate of the Number of Employees Whose Jobs Are Specification Sensitive: For Two-Digit DOT Occupational Titles With Over 500,000 Employees Impacted.

| Estimated Number of Employees Impacted | DOT Code | Occupational Title |
|---|---|---|
| 2,900,561 | 62/63 | Mechanics and Machinery Repairers |
| 2,021,402 | 86 | Construction |
| 839,538 | 00/01 | Architecture, Engineering and Surveying |
| 777,981 | 89 | Structural Work Occupations |
| 694,416 | 60 | Metal Machining |
| 652,406 | 91 | Transportation |
| 527,810 | 82 | Electrical Assembling, Installing, and Repairing |

Source: "The Effects of Metric Conversion on Measurement and Dimensional Sensitive Occupations" Final Report - Volume I - December 1980

EXHIBIT B-3

Estimate of the Number of Employees Whose Jobs Are Process Sensitive: For Two-Digit DOT Occupational Titles With Over 500,000 Employees Impacted.

| Estimated Number of Employees Impacted | DOT Code | Occupational Title |
|---|---|---|
| 3,545,877 | 18 | Managers and Officials |
| 2,012,336 | 31 | Food & Beverage Preparation Service |
| 917,856 | 21 | Computing and Accounting |
| 913,369 | 91 | Transportation |
| 885,256 | 90 | Motor Freight Occupations |
| 745,948 | 86 | Construction |
| 704,095 | 22 | Production & Stock Clerk & Related Occupations |
| 651,443 | 24 | Miscellaneous Clerical |
| 650,690 | 60 | Metal Machining |
| 612,747 | 25 | Sales Occupations, Services |
| 570,219 | 07 | Medicine and Health |

Source: "The Effects of Metric Conversion on Measurement and [illegible] Sensitive Occupations" Final Report - Volume I - [illegible]

# II. ALTERNATIVE STRATEGIES FOR METRIC CHANGE

In 1971 the National Bureau of Standards published a study entitled "A Metric America - A Decision Whose Time Has Come". Subsequently, many United States firms considered, and some initiated, efforts to change to metric measurement. While the concept of metric measurement is relatively simple, there has been little documentation regarding the alternative strategies that U.S. companies have used to accommodate metric change. As a result, many individuals are not sure exactly what metric change consists of and how it is accomplished. The purpose of this chapter is to clearly define the various elements of metric change and identify the alternative strategies that U.S. companies are using when they change to metric measurement.

## A. THE LANGUAGE OF MEASUREMENT

Before one can analyze the impact of metric change, a clear understanding must be established regarding the way measurements are used in our society. In this regard, it is important to understand the difference between how one measures something and what is being measured.

For example, as parents observe the growth of their children, they often measure their height and their weight. Traditionally this has been done using a scale that measures weight in pounds, and some kind of ruler or tape measure that measures height in feet and inches. Thus, the measurement units in this case are feet and inches for height and pounds for weight, while the item being measured is clearly the individual. If that same child were to be measured using metric measurement language, the units for height would most likely be centimeters and the units for weight would be kilograms. However, merely changing the measurement language from feet and inches to centimeters, or from pounds to kilograms, does not change the child from a customary child to a metric child. In fact, the person being measured has not changed at all.

In discussions about metric change within the United States, a great deal of confusion still exists about the relationship between the measurement languages and the items being measured. There are often references to metric machines or metric products, when in fact many of these products have not been changed in recent years. A product that was previously measured in customary units may now be measured using metric units, but this change in measurement language does not by itself create a metric product.

The single most important function of the modern metric system (Systeme Internationale d'Unites, or SI) is that it attempts to provide an internationally uniform measurement language that can be used throughout the world to measure all types of commodities and products without regard

to the language being used to express the spoken word. Thus, SI is supposed to be the same whether French, German, Russian, Chinese, or English is spoken. That uniformity which facilitates communication is, in fact, the primary contribution of SI. SI makes no attempt to provide for standardized sizes of products or standardized units of shipping. It merely tries to establish a uniform measurement language.

## B. THE IMPORTANCE OF STANDARDS

Ever since the Industrial Revolution, the importance of industrial standards has increased significantly. The use of standards was first initiated in the United States in the manufacture of firearms, particularly rifles with interchangeable parts. The value of these standards was that a part manufactured in one location would fit other parts manufactured in a different location; in short, the various parts were compatible. Thus, producing commonly sized items became a key element in manufacturing and industrial processes. As commerce expanded, the establishment of standardized units of measurement also assumed greater importance with respect to business transactions and the trading of commodities. With a barrel or similar container defined by a standard, the purchaser of a commodity knew exactly what quantity he was buying.

It is clear, however, that if one has a standard for purchasing a commodity, such as apples, then that standard can be defined as a bushel or container of a certain size in height and diameter. The measurement language used to describe that standard can be any one of a number of choices. That standard -- the bushel -- could be described in inches, millimeters, or some ancient Roman, Egyptian, or Chinese unit of measure.

The change in measurement language from customary to metric is but one element of a corporation's strategy for metric change. Many U.S. companies are changing from a measurement language that uses feet, inches, and pounds to a measurement language based on metric units. However, there is no reason to assume that this conversion requires a change in standards or sizes of standard products. It may include such changes, but only if there is some advantage to changing those standards.

## C. WHAT IS METRIC CHANGE?

The question of what metric change is appears to be easily answered; unfortunately, it is not fully understood by many people. The reason for this misunderstanding is that metric change varies considerably from one organization or corporation to another. In fact, a variety of options exist, all of which can be categorized as metric change. The nature of these options determines the strategy that may be employed by a corporation. Metric change can include all of the following elements:

- A simple change in measurement language from inch units to metric units. That is, replacing the use of all or most of the customary

units for length, mass, pressure, force, etc. with the corresponding metric units.

- A change in the physical sizes and standards of parts, components, or products sold by a corporation. This is called a hard metric change, and usually will involve the use of newly designed and rationally sized products. These will probably reflect even units of metric measure, such as even millimeters for length, even sizes for mass (250 grams, 500 grams, or 1000 grams), and even units in pressure (250 kilopascals or 100 megapascals).

- A soft metric conversion; that is, existing standardized products are given metric nomenclatures or names reflecting their approximate sizes in metric units, but the product is not changed. For example, the customary piece of lumber known as a 2x4 (which is not even close in actual measurement to two inches by four inches) might be renamed in metric to a 4x8, referring to four centimeters by eight centimeters as its approximate dimensions. As a second example, a one-inch steel plate which currently is referred to as "inch" steel might be renamed or specified as a 25 millimeter plate. Its actual size is not changed, but the tolerances are such that it is close enough to be referred to as 25 millimeter steel.

An individual change to metric may be based on one or more of the three basic elements described above; that is, a change in measurement language, a change in product sizes or standards, or a "soft" change in nomenclature. Over the past ten years, as U.S. corporations have individually developed strategies for metric change, they have incorporated in their strategies each of these approaches to a varying degree. Thus, each individual corporation strategy reflects differences with regard to what metric change is. Clearly, the extent to which a corporation applies these various concepts will have an impact on how individual workers respond to the conversion program, the tools the workers use, and the training that the workers will require.

## D. SOME LEAD, OTHERS FOLLOW

As with most changes in U.S. industry, the adoption of metric measurement units has resulted in different approaches to conversion. Some companies, convinced that there are substantial benefits to be gained from adopting a uniform measurement system throughout the company, have assumed a leadership position in metric change. For example, the use of one measurement language in the United States and a different one in overseas operations caused difficulties for many firms engaged in international trade. Such companies, like General Motors and Caterpillar Tractor, have initiated comprehensive, well planned, and thorough conversions to metric measurement. In this respect, these companies have assumed a leadership role in the U.S.

Other companies have chosen to follow -- some on the basis of studies which show the value of metric change, others because they have perceived a nationwide effort to move to metric measurement. These firms have generally tended to follow or react to the leaders.

In contrast, the majority of U.S. firms have been watching from the sidelines or responding to specific requests from the leaders to supply them with metric products. For example, the suppliers of firms like General Motors, Caterpillar Tractor, and Signode have been requested to provide components using metric drawings or to redesign products to new standards and sizes using rational metric measures and metric fasteners.

The decision that an individual corporation makes regarding metric change -- that is, to lead, follow, or watch -- has a major impact on the way it implements its strategy. Those firms that are aggressively leading metric change seek out every opportunity to benefit from the change (i.e., rationalization of sizes, reduction in inventories, or simplified designs). The companies that are merely responding to specific requests from a customer may only consider metric change in light of a specific product or project or because of a competitive situation.

Those firms with a majority of their customers moving to metric measurement (and, in many cases, requiring newly designed products) must, in the interest of competition, move in the same general direction as their customers. However, their motivation to convert is very different. They do not change to metric to achieve anticipated benefits; they do it to maintain their business. Each of these choices regarding the overall approach to metric change has various impacts with regard to how a corporation addresses its worker tool issues and worker training issues.

## E. INDEPENDENCE OR INTERDEPENDENCE

Each U.S. corporation is tied, in varying degrees, to its suppliers, customers, or competitors. To the extent that these ties are limited and do not have major impacts on the business strategy, these companies are independent of the other organizations. On the other hand, to the extent that firms have major outside suppliers, or major customers demanding specifications or standards, they are quite interdependent. The nature of any individual corporation's interdependence on others or the extent of its independence from everyone else has a substantial bearing on its metric change strategy. If a corporation manufactures most of its parts, creates its own designs, and provides maintenance and replacement parts through its own channels, it is relatively independent of the rest of the world. Under these conditions, the decision to use metric measurement units or change the sizes of standard products to rational metric sizes can be made without undue concern about the impact such a conversion will have on other firms.

In contrast, to the extent that a corporation has a large number of independent suppliers (for example, General Motors), or has a wide range of customers (i.e., U.S. Steel or Alcoa Aluminum), or sells internationally

standardized products (such as The Timken Bearing Company), it is quite interdependent with outside forces. An organization that has many interdependencies must carefully consider a proposed metric change strategy before it is actually implemented. Without careful planning, substantial problems may result; a supplier might be unable to provide parts using metric drawings, or a customer might resist buying products designed in metric units. A few interdependent corporations, such as General Motors, have the power to directly influence their suppliers or customers.

## F. CAPITAL EQUIPMENT IMPLICATIONS

In many firms, the change to metric measurement or the use of metric standards will have implications for the capital equipment associated with the industry. These implications can range from minor modifications and adjustments to major replacements or overhauls of capital equipment. Thus, the particular metric change strategy that a firm ultimately selects may be dictated, at least to some extent, by capital equipment factors of the industry in general or within the company itself.

Capital equipment that is used in highly automated production line facilities, such as automobile plants, may be easily modified to adjust to metric sizes or metric standards through the normal retooling process associated with a model change. In other industries, such as the production of sheet steel or aluminum, the production of raw materials in even millimeter sizes can be accomplished by adjusting the thickness of the rollers with a digital readout device or other soft conversion mechanism. These same digital readout devices can be attached without difficulty to most machine tools, and thus, easily accommodate either metric or inch measurement in a production facility. In contrast, the production of structural steel shapes, such as I beams, angle iron, or H columns, requires expensive dies which must be manufactured to some pre-established new standardized sizes. The capital equipment associated with the production of metric sized structural products is quite expensive, and this capital cost will influence any decision to accommodate metric sizes within that industry.

## G. EACH STRATEGY HAS DIFFERENT IMPACTS

When the U.S. industries that have experienced metric change are analyzed, it is clear that each has a unique strategy with regard to the implementation of metric measurement. These strategies vary considerably, and each has different impacts with regard to worker tools and worker training. The major variables influencing the selection of a strategy and the alternative strategy options are tabulated in Exhibit C. The corporations studied were analyzed in light of their particular strategy. Exhibit D illustrates the various impacts on worker tools and worker training that a particular strategy may have. Exhibit E shows the impact on career issues and complementary issues. A particular strategy can determine such things as:

- The extent to which a corporation addresses the initial cost of new metric tools for workers.
- The nature and extent of metric training provided by the corporation.
- The extent to which a corporation will accommodate metric tools or training in a collective bargaining agreement.

## H. STRATEGIES ARE BOTH FORMAL AND INFORMAL

Each corporation that has become involved in metric change has taken its own approach to determining its metric change strategy. Some companies have made rather thorough analyses and have established a formal metric strategy. Examples of these organizations include General Motors Corporation, Caterpillar Tractor, and Signode Corporation. Other companies have taken a less formal approach to establishing a metric change strategy. Often this informal approach is a result of individuals working in engineering standards activities that have become involved in metric change as an outgrowth of the standardization process at the corporate level.

EXHIBIT C

VARIABLES THAT INFLUENCE THE ADOPTION OF A STRATEGY

| VARIABLE | OPTIONS EXHIBITED BY U.S. FIRMS | | |
|---|---|---|---|
| Dependence | Very independent of others | Highly dependent on suppliers | Highly dependent on customer demands |
| Power to Influence | Has little power to act independently | Can direct suppliers to use metric | Can influence customers to buy metric |
| Capital Equipment | Only requires tooling changes to accommodate metric | Can easily be modified by adding digital readouts | Major capital investment required to accommodate metric |

ATTRIBUTES OF METRIC CHANGE STRATEGIES

| ATTRIBUTE | STRATEGY OPTIONS ADOPTED BY U.S. FIRMS | | |
|---|---|---|---|
| Use of Measurement Language | Use only SI | Mixed use of both SI and customary | Use only customary measurements |
| Use of Engineering Standards* | Use all metric standards | Use both metric and inch standards | Use only inch standards |
| Pace of Metric Change | Introduce metric into all new designs | Use metric on some projects | Resist the use of metric |
| Industry Position | Leader in metric use | Follower | Observer |

* Note: Standards may be Company, Industry, United States, or International

EXHIBIT D

IMPACT OF METRIC CHANGE STRATEGIES

ON TOOL AND TRAINING ISSUES

| REPRESENTATIVE CHANGE STRATEGY OPTIONS | POTENTIAL IMPACT | |
|---|---|---|
| | TOOL ISSUES | TRAINING ISSUES |
| Mixed Use of Both SI and Customary Measurement Languages | Should not directly impact tools | Requires worker knowledge of both languages |
| Use of Both Metric and Inch Standards | May require workers to use both metric and inch tools | Requires worker familiarity with both standards |
| Introduction of Metric Into All New Designs | | |
| . Production | Workers use gauges and metric tools on new products; | Opportunity for company-wide training program |
| . Maintenance | Workers may need metric tools to maintain equipment; | Opportunity for company-wide training program |
| . Service | Servicemen need both metric and inch tools | Opportunity for company-wide training program |
| Introduction of Metric Into Selected Products | | |
| . Production | Workers use gauges and metric tools only on metric projects; | Training in plant limited to project team |
| . Maintenance | Workers may need metric tools to maintain equipment; | Training in plant limited to project team |
| . Service | Servicemen need only metric tools for metric products | Training in field limited to servicemen assigned to product |

EXHIBIT E

IMPACT OF METRIC CHANGE STRATEGIES

ON CAREER AND COMPANION ISSUES

| REPRESENTATIVE CHANGE STRATEGY OPTIONS | POTENTIAL IMPACT | |
|---|---|---|
| | CAREER ISSUES | COMPANION ISSUES |
| Mixed Use of Both SI and Customary Measurement Languages | Does not appear to have any impact | Could impact safety or productivity |
| Use of Both Metric and Inch Standards | Does not appear to have any impact | Could impact safety or productivity |
| Introduction of Metric Into All New Designs | | |
| . Production | Does not appear to have any impact | Could impact safety or productivity |
| . Maintenance | Does not appear to have any impact | Could impact safety or productivity |
| . Service | Does not appear to have any impact | Could impact safety or productivity |
| Introduction of Metric Into Selected Products | | |
| . Production | Does not appear to have any impact | Should have no impact |
| . Maintenance | Does not appear to have any impact | Should have no impact |
| . Service | Does not appear to have any impact | Should have no impact |

# III. STUDY METHODOLOGY

This section of the report outlines the plan developed to conduct the study of metric tool and training issues. It describes our approach to the study and outlines the methodology used in selecting sites, collecting data, and analyzing the results.

## A. PROJECT PLAN

The major sections that follow describe each of the project tasks and subtasks. Where these tasks produced a deliverable product, the product is identified; in addition, where these tasks required some decision or concurrence on the part of the U.S. Metric Board, that is also indicated.

### 1. Develop A Project Plan

Following initiation of the contract and the initial planning meeting, a detailed project plan was developed. The project plan was an expansion of the tasks outlined in the proposal and included a detailed schedule for completion of the tasks. The plan outlined the organizations and individuals to be visited, when they would be visited, what data would be collected, and how the data would be tabulated or analyzed.

### 2. Select Occupations

The research team analyzed the results of the Phase IA study to determine the specific occupations that should be studied during this effort. The team recommended to the research staff of the U.S. Metric Board that 20 occupations be studied in-depth. Based on the preliminary results from the FY 1980 study, occupations were selected from the following categories:

- Mechanics and machinery repairers
- Construction and structural workers
- Metal machining occupations
- Packaging and materials handling
- Transportation and motor freight occupations
- Electrical assembly, installation and repair.

These are the occupational categories that were identified in Phase 1A of the AMS study as having the greatest number of workers with the highest level of metric sensitivity.

The criteria for selecting the specific occupations included:

- High sensitivity to metric change
- Established proficiency testing
- Defined career ladders
- Easy access to data
- Commonality of tool requirements.

Based upon initial project meetings and a review of the data collected during Phase 1A, 20 occupations were tentatively selected for analysis. These are shown in Exhibit F. Appendix II shows the entries in the Dictionary of Occupational Titles that correspond to each occupation. Some highly sensitive occupations, such as teachers, engineers, and scientists, were not reviewed in this study. They were eliminated from the analysis due to the USMB's desire to focus on craftsmen, manual laborers, and clerical workers.

Thus, rather than choose stratified random samples from the populations of all U.S. occupations and industries, a non-probabilistic[2] but typical sample based upon knowledge of the population was selected. The fact that the occupations and industries selected are only an illustrative sample limits the extent to which statistical inferences can be drawn regarding the broad range of U.S. occupations.

### 3. Establish Advisory Group

An advisory group was established by selecting representatives from labor, vocational education, and business to provide a group of five members. The purpose of the advisory group was to assist the team in selecting the occupations to be studied, finalizing the methodology, and developing conclusions. The group also reviewed and commented on the draft final report.

The advisory group met for one-day sessions twice during the course of the study. MRC organized the advisory group; recommended potential participants to the Metric Board staff; and upon USMB's concurrence, arranged for the organization and conduct of each meeting.

The advisory group was provided with highly structured materials in advance of each meeting. Each meeting was designed to deal with specific issues and to arrive at a consensus regarding those issues. The advisory group members were:

[2] A non-probabilistic sample such as this is often referred to as a purposive sample.

- Andrew S. Korim - West Virginia State College, Community College Component

- Ernest Stinsa - International Harvester Co.

- Paul Vandiver - U.S. Department of Labor

- Ted Reed - International Union of Operating Engineers

- Jacob Kaufman, Ph.D. - New York School of Industrial & Labor Relations

4. Develop Research Methodology

To gain an insight into the effect of metric change on workers, a variety of research techniques were considered. The development of case histories was determined to be the most effective given the need for accurate data and the limited project resources. The team believed that the sensitivity of the Worker Tool and Training Study was such that face-to-face interviews and similar data gathering techniques had to be used in order to provide the Metric Board with accurate and understandable information. Therefore, questionnaires were not used in gathering data for this study.

5. Develop Data Sources

The MRC staff worked with its existing contacts throughout the country, union leaders, the advisory group, and the Metric Board research staff to identify data sources. Such sources included unions, trade schools, business organizations, trade associations, and others with a common interest related to labor issues, training, or employee working environments. These data sources were selected particularly for the accessibility of data that they offered.

The actual sources varied considerably for the individual occupations selected for study. For example, since mechanics or machinists were one group of occupations being studied, the International Association of Machinists and Aerospace Workers was a logical source of data. The Association was particularly helpful in identifying union locals that would be cooperative in a data gathering effort. For other occupations, the International Brotherhood of Electrical Workers and the International Brotherhood of Carpenters and Joiners were two logical starting places for union contacts.

A number of business firms throughout the country are working in metric units at this time. Each of these has gone through a metric conversion program that frequently included a training program. Such firms as Caterpillar Tractor or the Timken Company have had metric training programs in

the past. These firms and others were contacted to determine the availability of training data with regard to the specific occupations we analyzed. Access to non-union employees was established by telephone screening of these firms.

## 6. Collect Data

The data collection activities consisted of three interrelated phases: research, telephone contacts, and on-site visits. Although each of these data collection activities was conducted independently, there is a logical relationship. The research phase identified a number of individuals and organizations to be contacted, while the telephone contact phase was used as a screening device to gather advance information and to determine which companies should be considered for on-site visits. The nature of the three phases was as follows.

### a. Research

A primary focus of the research phase was to identify those businesses throughout the country that have actually experienced some degree of metric conversion and have firsthand experience relating to metric tools and metric training. A literature search was conducted to identify the extent to which various career enhancement techniques are utilized in the specific occupations studied. Once this was determined, an attempt was made o identify which businesses were actually employing practices such as job enhancement, job rotation, or job enrichment.

### b. Telephone Contacts

An extensive amount of telephone research was done to identify field contacts with relevant historical data, factual information, and metric experience. This telephone activity included calls to local unions, businesses, professional associations, educational organizations, and others who might have information valuable to the study. These telephone contacts were used both to solicit materials and to identify unions and businesses for potential on-site visits.

### c. Site Visits

A number of union locals, businesses, and training organizations were identified for on-site visits. These visits were arranged so as to achieve a maximum amount of data gathering for a minimum amount of travel expenditure. The emphasis of each site visit was to gather firsthand knowledge and experience regarding tool, training, and career issues. The advisory panel was queried regarding ideas for potential site visits, as well as to facilitate data access. Before each visit, the consultant or consultant team prepared a specific list of data to be gathered from each of the participants. While these data lists had general uniformity across the study, the actual data to be collected during each site visit was

tailored to the nature of the organization being visited and the individual(s) who were interviewed.

### 7. Analysis and Final Report

Upon completion of the data collection phase, the team conducted a comprehensive analysis of the data gathered. This analysis focused on specific issues relating to tools, training, and careers, and also considered the integrated effect of the issues. One purpose of the analysis was to provide a thorough examination of all of the relevant issues pertaining to metric change within the 20 occupations selected for study. In addition, the analysis focused on the identification of specific areas of metric change that the Metric Board should consider for study in future years. As a last step in the analysis, specific conclusions and recommendations were developed based on the findings of the study.

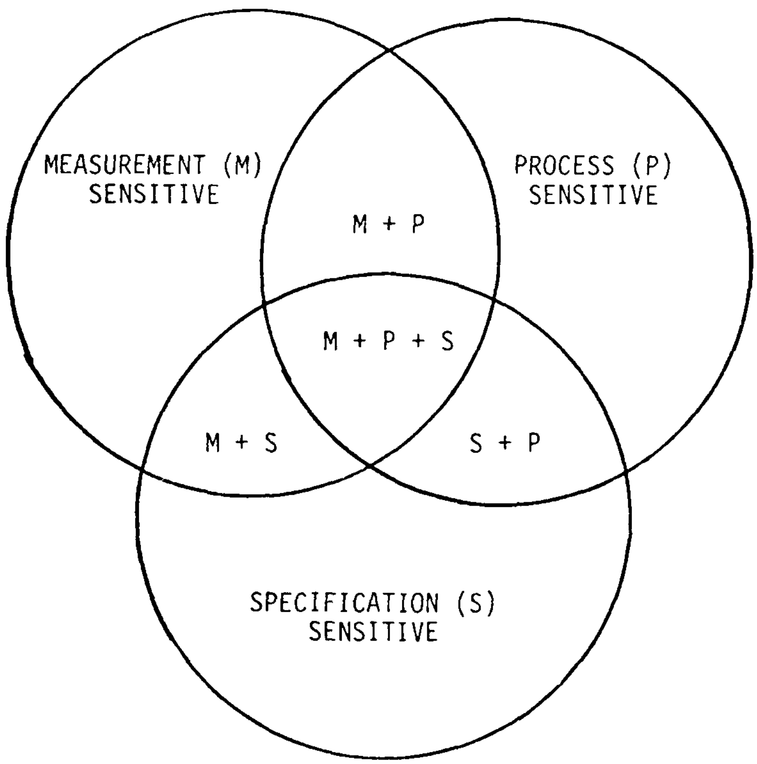
## B. REVIEW OF PHASE 1A DATA

The study plan used the basic structure for metric sensitivity that was developed in Phase IA, although a slight change was made in the title of one category (from dimensional to specification sensitive). The categories used are described below and are also shown in Figure 1, which follows this page.

- Measurement sensitive. Jobs that are measurement sensitive require the measurement of things and the use of tools or instruments involving measurements. Some examples are: a home economist who develops and tests recipes where measurement of the ingredients is involved; an industrial designer who prepares detailed drawings involving measurement dimensions; a parcel post clerk who determines the weight of parcels in order to apply the correct postage; a tool and die maker who produces parts from detailed drawings; or an automotive mechanic who uses a torque wrench or air gauge to measure various items and runs tests using a dynamometer to measure speed, fuel usage, exhaust emissions, etc.

- Specification sensitive. This category includes those jobs that use things defined by standards and uniform specifications (i.e., sheet metal thickness, wire size, tool sizes, drill sizes, etc.). Examples of jobs in this category are: a punch press operator who tends one or more power presses and loads them with steel of a specified gauge; an electrician who uses wire specified by gauge; a machinist or mechanic who uses wrenches defined in inch or fractional inch sizes; or a drill press operator who changes drills from time to time but identifies the drill by the established drill number, letter, or fractional inch size and not by measurement of the drill diameter.

PICTORIAL DIAGRAM SHOWING TYPES OF METRIC SENSITIVITY




OCCUPATIONS EXHIBITING METRIC SENSITIVITY

| Sensitivity | Example |
| --- | --- |
| Measurement Only | Bricklayer |
| Process Only | Secretary |
| Specification Only | Parts Inventory Clerk |
| Measurement & Specification | Mechanic |
| Measurement & Process | Laser Technician |
| Process & Specification | Sales - Petroleum/Chemicals |
| Measurement, Process & Specification | Master Tool & Die Maker |

FIGURE 1

- Process sensitive. This category includes those jobs that use measurement information in performing a job (for example, tabulation of inventory or maintenance of records in which measurement units are involved). Examples of this type of job are: medical records personnel who deal with patient information in measurement units, but do not actually perform the measurement; real estate agents who routinely use lot size and building size in real estate transactions, but do not themselves make the measurements of those items; a technical writer or technical proofreader processing material that includes technical content relating to measurement units; and inventory or stock clerk personnel who maintain records of material in measurement units, but do not themselves perform the measurements.

- Not sensitive. These jobs do not require measurement activity or the use of measurement units in any of the above three ways.

## C. ANALYTICAL FRAMEWORK

To provide a structure for the analysis of data, the team developed an analytical framework for addressing the major issues of the study. This analytical framework identifies the major elements of methodology associated with the three issues required by the study. In addition, specific cost structures were identified to be used in comparing and tabulating the cost data.

### 1. Tool Issues Methodology

The approach to gathering tool issue data within the selected occupations was to try to identify, for each occupation, a standardized tool inventory list. Typically, these tool inventory lists are provided by unions, apprentice programs, or businesses to establish a minimum level of tools required for employment in a particular occupation and sometimes at a particular skill level within an occupation. In most cases, these tool lists can be used as a benchmark to define what basic set of tools an individual employee must have in order to perform his work in an entry level position within an occupation.

After reviewing each occupation to determine the various skill levels within that occupation, the team interviewed individuals to determine what tools might be required in a more advanced level of performance. These tools were added as supplemental lists to the basic tool inventory. Once this family of tool inventories was established for each occupation, the lists were evaluated to determine which tools were measurement sensitive. This task is relatively simple once a tool inventory is established. Those tools which are actually used to measure are easily discernible from those that are not. For example, rulers and micrometers are used to measure, while hammers and screwdrivers are not. However, hammers and screwdrivers are often nomenclatured by weight, such as a 16-ounce hammer or an inch

screwdriver. Other tools that are sized and, thus, are measurement sensitive (for example, wrenches) are also easily identified. Once the measurement sensitive tools were identified, they were to be analyzed to determine how metric capability can be acquired. That is, must the tools be replaced; are dual measurement capabilities possible; or will two sets of tools be required for a long period of time? Examples would be as follows.

- A ruler at some point must be changed to provide metric capability. This can be done by buying a metric ruler when a worker needs one or when the current one breaks, or it can be done by buying a dual dimensioned ruler. Purchasing a dual dimensioned ruler would be less expensive than buying both metric and inch rulers; however, dual dimensioned rulers can be confusing.

- Socket wrenches or box wrenches are sized to fractional inches. Generally, they will not fit on metric bolts or nuts; therefore, a mechanic must purchase a separate set of metric wrenches sized in even millimeter increments to deal with metric units. In order to be proficient in both units of measurement, the mechanic will have to use both sets of wrenches for some period of time during the metric transition period.

- Some tools can be provided with metric capability simply by replacing a portion of the instrument. An example of this would be a combination square set, which typically includes a square head, center head, and protractor head. Since the heads themselves are not measurement sensitive, only the blade needs to be replaced to accommodate metric units. A combination square set with both an inch blade and a metric blade would provide dual capability throughout the transition period. The cost of purchasing a second blade is much less than that of purchasing a complete new set.

Once the nature of the individual tools required for each occupation and the extent of metric impact were determined, the approach to replacement of these tools was examined. This typically is a function of the employment situation for each individual. That is, does he have his own tools and is he responsible for replacing them? Does his employer provide for tool replacement? Will his employer provide for metric tools on a replacement basis? Does the union's contract specify that an employer must provide all new metric tools? Each of the issues was to be explored through interviews with representative individuals in the firms visited.

The way in which tool acquisition policies vary was analyzed to determine the relative factors that impact the direct cost to the individual. Figure 2, which follows this page, summarizes the basic tool replacement issue and shows the alternative decisions required for acquiring individual tools.

The major steps that were used in developing tool issue data for analysis are as follows:

## TOOL ACTIVITY DECISION TREE

WORKER HAS NORMAL TOOLS OF THE TRADE AVAILABLE IN "INCH" SIZES

| | Results / Actions | Individual Tool Duplication | Maintains Dual (Inch & Metric) Capability | Increased Cost to Individual |
|---|---|---|---|---|
| TOOL REQUIRES NORMAL REPLACEMENT | Individual Buys New "Inch" Tools | NO | NO | NO |
| | Individual Buys New "Metric" Tools | NO | NO | MAYBE(1) |
| | Acquire "Dual" Tools | NO | YES | MAYBE(2) (3) |
| JOB REQUIRES METRIC TOOL(S) | Acquire New "Metric" Tools | YES | YES | MAYBE(3) |
| | Acquire "Dual" Tools | YES | YES | MAYBE(3) |
| | Use Company Owned "Metric" Tools | NO | YES | NO |

(1) If metric version costs more than inch version
(2) If dual version costs more than inch version
(3) Depends upon who pays for tool, i.e., individual vs. employer

NOTE: "acquire" may mean individual buys or company buys

FIGURE 2

- Select occupations
- Obtain tool inventory lists
- Identify employers with relevant experience
- Solicit available data
- Screen potential site visits based on:
  - occupations of interest
  - extent of metric experience
  - receptivity of employers/employees to the visit
- Collect on-site data
  - which tools are owned/used?
  - what tools are replaced?
  - what was the cost?
  - who paid for the tools?
- Tabulate site visit data
- Collect tool catalogues
- Tabulate tool cost data from catalogues.

2. Training Issues Methodology

For each of the occupations identified for the study, the team investigated the alternative methods for delivery of occupational and skills training. This was done by establishing contacts with technical schools or institutes, vocational/trade schools, union/management programs, apprenticeship training programs, and suppliers of films and audio-visual aids. The nature of routinely-provided training for each skill level was identified for the individual occupations. Each type of training was examined to establish how much of the content was measurement-oriented. In addition, the individuals involved were to be interviewed to learn the extent to which metric training was accomplished in these programs. During this process, we attempted to verify the findings of the earlier study with regard to measurement units that are actually involved in the workplace. Phase IA of that study indicated that only six measurement units are used more than ten percent of the time in the jobs that were studied. Those measurement units and the percentage times that were mentioned are:

- Length 69%
- Mass 40%
- Volume 35%

- Area 32%
- Temperature 22%
- Pressure 18%

Thus, metric training efforts in most occupations appear to be limited to providing the employee with an understanding of metric units and how they are used in his particular occupation. The nature of training provided by each of the sources was investigated to determine who provides the training; who bears the cost of training (that is, the individual, the company, the union, the government); and how the training varies at different levels of proficiency. For each occupation, the training programs were classified by level or type of training. Where red circling[3] was used to identify individuals whose career growth appeared to be limited, we investigated, to the extent possible, the impact of training programs on such practices.

The major steps that were used in collecting data for training issues are as follows:

- Select occupations
- Obtain lists of apprentice programs
- Identify employers with relevant experience
- Determine apprentice programs with relevant experience
- Solicit available data
- Screen potential site visits
  - occupations of interest
  - extent of metric experience
  - receptivity of employers/employees
- Collect on-site data
  - what metric training was presented?
  - what was the cost of metric training?
  - who paid for the metric training?
  - how was the metric training conducted?
- Tabulate site visit data
- Collect training package catalogues and costs
- Tabulate training cost data from catalogues.

3 Red circling is a technique used to annotate personnel records and indicate those older workers who have reached the limit of their career growth.

### 3. Career Issues Methodology

The career issues delineated in the study's original Statement of Work related to career mobility. Career mobility is the degree to which a worker can move either vertically or laterally, or adapt to new requirements. It is affected by both the individual's abilities (skills, knowledge, etc.) and the nature of the occupation. An individual's abilities, though more than adequate for one task, must also be transferable and adaptable to either related or totally different tasks in order for an individual to have career mobility. A job which is either measurement, specification, or process sensitive requires that a worker be able to use a particular system of measurement. Changing that system may preclude certain workers, who do not have this measurement skill, from entering a job category. This requires that developmental training be made available to those individuals.

Job enrichment, job rotation, and job enlargement are management concepts which were applied in certain industries to increase job satisfaction. The most notable application was the Volvo experiment, where the traditional assembly line was replaced by a team approach. The team was responsible for building the entire car rather than just the assembly of a component. Job enrichment, job rotation, and job enlargement were designed primarily to make jobs more interesting and meaningful by increasing responsibility and skills and decreasing routinization and alienation. They are career path issues only to the extent that if an industry or occupation applies the practices, then certain workers may have to learn new skills to remain mobile.

Career ladders, vertical and lateral changes, and specialization are more directly related to career mobility. They are the opportunities, within a broad occupational category, for a worker to move from one position to another. Occupations may have prescribed, highly formalized mobility patterns with controlled entry; loosely defined and individually controlled mobility patterns; or a combination of both. Factors affecting this are:

a. Degree of skill required
b. Licensing or certification required
c. Training required
d. Age of occupation/how long it has been around
e. Specialization

The approach to the analysis of career issues included the following:

- A literature search to determine the extent of usage by industrial employees in the industries to be studied.

- Interviews with unions, management, and individual workers to determine degrees of mobility for a given occupation.

- Interviews to determine if requiring a new skill in selected positions within an occupation impacts career mobility more than requiring a new skill across the board.

- Evaluation of the impact of career issues from three perspectives: individual, union, and industry.

Elderly workers and metric change was also investigated. In addressing the issue of the impact of metric change on older workers, we gathered data from the Department of Labor and the National Council on the Aging. It was also anticipated that some research had been conducted by the unions on older worker training.

4. Companion Issues Methodology

A variety of issues were identified as companion or secondary issues for this study. In each case, the team conducted various research activities, such as computer searches, literature searches, or other general analysis, to identify existing materials relevant to the companion issues. We documented our findings in these areas only to the extent necessary to provide an input to the USMB so that they can determine whether these issues warrant more extensive research in future years.

Safety Issues: In conducting the study, the team identified safety issues related to the 20 occupations that were studied in-depth. During the data gathering efforts, we collected whatever information was available regarding currently existing safety practices and safety training. The extent to which safety issues will be impacted by a change to metric measurement was examined. As an example, truck mechanics have for many years been exposed to a high risk associated with over-inflation of truck tires. This occurs most frequently when multi-part rims are used. However, the factors that are involved in this safety is[illegible] include assembly of the rim itself and then inflation of the tire to the [illegible]oper air pressure. While replacement of multi-part rims with newer and safer designs is expected to reduce the hazard, accidental over-inflation is still a potential problem. To the extent that the change in indication of air pressure from pounds per square inch to kilopascals could confuse a mechanic and therefore increase the safety hazard, then metric change could have some impact on the risk associated with the occupations. In this particular case, however, it may be difficult to sort out the issue of over-inflation from improper assembly of the multi-part rim. In cases where safety issues were relevant to the 20 occupations studied, the issues were analyzed in terms of metric conversion.

Collective Bargaining: The study team defined the impact of metric change on the collective bargaining process. In the past six years the issue of metric tools, and to some extent metric training, has become an element of union negotiations; and in some cases these issues have been reflected in national labor contracts. The team conducted research through union representatives and selected industries to determine what experience

the U.S. has had to date with metric issues in regard to contract negotiations. The issues that were addressed included: What is the nature of metric conversion issues with regard to collective bargaining? Can they be used to delay the collective bargaining process? Can collective bargaining be used to easily resolve metric training and tool issues in particular situations? To what extent do the issues identified throughout the study have a specific impact on the collective bargaining process?

Productivity Issues: Since the overall impact of a change to metric measurement may, during some transitional period, make an individual worker or group of workers less comfortable with their work environment, this could to some extent impact productivity. Such impacts could result in slight delays while workers do things more cautiously; in increased errors because workers are unfamiliar with the new measurement units; or in some cases, a decrease in errors because the workers are being overly cautious. In any case, the impact of metric change on productivity was completely unknown at the initiation of the study. Therefore, to the extent that productivity factors were a major element in the occupations analyzed, the team investigated, on a preliminary level, how metric change impacts productivity. This analysis is a first step in establishing a baseline for future in-depth analysis that the Metric Board may wish to consider on productivity and metric conversion issues.

Tax Issues: Tax issues were also addressed as part of the study. We utilized some of the initial data collected during a previous study regarding the effect of tax deductions on tools and training. Then, in conducting the current research effort, the team studied the issue of tax deductions or credits while collecting data during site visits.

### 5. Cost Structures

A key element in the study was developing a comprehensive cost structure for tool costs and training costs. These cost structures were developed prior to the field visits so that interviews could be organized to collect the required cost data. The cost structures are shown in Exhibits G and H. In collecting this cost data, the focus was on the following cost items:

- The magnitude of incremental costs associated with the introduction of metric measurement;
- Identification of who will bear these costs (i.e., industry, individual, union, or others);
- Differentiation between the tools that a worker would like to have and the tools that are considered essential for performance of a basic skill (that is, individual pride in or desire for "top" quality tools may tend to inflate costs); and

. Identification of the costs of not training or not providing metric tools.

## D. IDENTIFICATION OF DATA SOURCES

In order to collect the data required for this study, open-ended interviews were conducted at companies that have had experience in hard metric conversion and are knowledgeable about the issues of worker tools and training. The site selections were made after a careful screening of the organizations that claimed to have hard metric conversion experience. The criteria for the site selections were as follows:

1. Actual hard metric conversion of some kind which affected workers in the occupations that were identified as being most measurement sensitive;

2. Willingness of both management and labor to communicate their experiences;

3. Evidence that an objective and unbiased report on their conversion experience could be provided to us by management and labor; and

4. Close proximity of the sites to be visited for purposes of maintaining costs within the contract limit.

To identify the most valuable sources of relevant data, a variety of data sources were reviewed. The focus of this review was to identify U.S. organizations with actual "hard" conversion experience in a variety of industries. The steps performed in selecting data sources were as follows:

1. Review of metric media materials, such as The U.S. Metric Association Newsletter, The Metric Reporter, and the extensive library at Middlesex Research Center. The purpose of this review was to identify those companies and individuals who have been mentioned as having some metric conversion experience, or to identify organizations that have given support to companies in a h[illegible] metric conversion mode.

2. Development of a computer-generated matrix showing organizations' metric activities and project team contacts with these organizations.

3. Telephone screening of those organizations on the matrix which appeared to have the most potential for providing the information needed. Part of this telephone canvassing exercise was designed to identify the labor and management individuals within the organization who could provide the necessary data.

4. Development and prioritization of a list of potential site visits for the in-depth study.

5. Identification of tools used in the 20 occupations to be studied.

6. Collection of tool catalogues from the various metric suppliers.

7. Identification of alternative training programs for the 20 occupations to be studied.

## E. SITE VISITS AND DATA COLLECTION

Each site visit required between one-half day and one full day of interviews on the part of two team members. The project team interviewed both middle management and labor representatives whenever possible. An interview guide was used to plan the site visits. However, the interviews were not limited to a discussion of the materials in those guides. The guides simply provided some format and structure for the open-ended interviews. During the telephone screening prior to the site visits, we identified specific data that could be provided in advance. This included training cost data, tool lists, or other specific data relevant to the study. An example of the confirming letters sent in advance of each site visit is shown as Exhibit I. After the site visits, additional information was gathered by follow-up phone calls and letters as required.

In addition to the data obtained during the site visits, data was gathered from a variety of other sources. This included a review of a number of publications, such as automobile service manuals, training materials developed by various organizations and used to conduct metric training programs, materials provided by the American National Metric Council, and other documents. Some information concerning training activities in the western part of the United States was gathered through mail and phone contacts with organizations involved in the delivery of metric training programs. Site visits to these states were not considered due to the limited project budget. A list of additional data sources utilized in the conduct of the study is provided as Exhibit J.

## F. ANALYSIS OF THE DATA

Upon completion of the data collection phase, the team conducted a comprehensive analysis of the data gathered. This analysis focused on specific issues related to tools and training, and also integrated the companion issues. The primary purpose of the analysis was to provide a thorough examination of all relevant data with regard to metric conversion within the 20 occupations identified for the study. In addition, the analysis focused on the identification of specific areas that the Metric Board could consider for future research activities. As a last step in the analysis, we developed specific conclusions that concisely state the findings of the study. The tasks performed in analyzing the results of the study are briefly described below.

1. The raw data collected from each site visit were reviewed, and a narrative summary of each trip was developed. Drafts of the summaries were returned to the field sites so that appropriate individuals could review and comment on them before they were finalized. These summaries have been included as part of Appendix IV in this report.

2. The data from each visit were analyzed to identify the specific components associated with tool costs, training costs, and the complementary issues. When this analysis revealed inconsistencies in the data or raised additional questions, the individuals who had been interviewed were contacted and additional information was requested to clarify any issues that arose.

3. The data from all site visits were tabulated in a variety of displays, so that comparisons could be made regarding key variables associated with tool, training, career, or companion issues. These tabulated data are provided in Chapter IV. While the sample size is not statistically significant, in light of the large population involved, the data do indicate certain consistencies with regard to the range of training costs and tool costs, and the general approach being used within industry to accommodate metric change.

4. The final step in the analysis was to interpret the results and to identify the commonalities, ranges of variables, key findings and conclusions that were observed.

All of the cost data from the site visits were reviewed and conclusions were developed about the following:

- Range of tool and training costs by occupational areas;
- Identification of parameters that impact tool and training costs, such as union membership, skill levels, or occupations;
- Typical impact of these costs on industry, individuals, or unions;
- General applicability of cost data from this study to other metric conversion situations;
- Areas that warrant additional study by the USMB; and
- The nature of any non-cost impacts associated with metric measurement and individual worker tools or training.

EXHIBIT F

# RECOMMENDED OCCUPATIONS FOR STUDY

| | |
|---|---|
| 502 | Melting, pouring, casting, and related occupations |
| 600 | Machinists and related occupations |
| 601 | Toolmakers and related occupations |
| 616 | Fabricating machine occupations |
| 620 | Motorized vehicle and engineering equipment mechanics and repairers |
| 621 | Aircraft mechanics and repairers |
| 622 | Rail equipment mechanics and repairers |
| 625 | Engine, power transmission, and related mechanics |
| 633 | Business and commercial machine repairers |
| 771 | Stone cutters and carvers |
| 810 | Arc welders and cutters |
| 820 | Occupations in assembly, installation, and repair of generators, motors, accessories, and related powerplant equipment |
| 821 | Occupations in assembly, installation, and repair of transmission and distribution lines and circuits |
| 822 | Occupations in assembly, installation, and repair of wire communication, detection, and signaling equipment |
| 827 | Occupations in assembly, installation, and repair of large household appliances and similar commercial and industrial equipment |
| 860 | Carpenters and related occupations |
| 861 | Brick and stone masons and tile setters |
| 862 | Plumbers, gas fitters, steam fitters, and related occupations |
| 899 | Miscellaneous structural work occupations |
| 953 | Occupations in production and distribution of gas |

EXHIBIT G

## METRIC TOOL COST STRUCTURE

A. Cost of purchasing replacement metric tools

- Employer costs
- Employee costs

B. Cost of purchasing duplicative metric tools

- Employer costs
- Employee costs

C. Incremental cost of maintaining both metric and inch tools

- Employer costs
- Employee costs

D. Cost of productivity changes due to the use of two tool sets

E. Offsetting costs from tax deductions or other reimbursement mechanisms

EXHIBIT H

## METRIC TRAINING COST STRUCTURE

A. Cost of developing metric training materials

B. Cost of purchasing metric training materials

C. Delivery costs for metric training

- Individual training
- Trainer costs
- Facility costs
- Lost job time costs
- Extra employee time required

D. Incremental costs due to changes in productivity from using two measurement systems

E. Individual earnings increases or decreases as a result of using two measurement systems

F. Possible cost offsets due to reimbursements

EXHIBIT I

MRC

MIDDLESEX RESEARCH CENTER, INC.

3413½ M STREET, N.W. • WASHINGTON, D.C. 20007 • (202) 333-1925

16 April 1981

Mr. Rolf Sheu
Bosch Diesel Injection
P.O. Box 10347
Charleston, SC 29411

Dear Mr. Sheu:

I appreciate the time you took to talk to me regarding the metric activities of Bosch Diesel Injection. As I mentioned, I am conducting a small research study for the U.S. Metric Board. The objective of the study is to obtain factual data from U.S. companies regarding the impact of metric conversion on blue collar workers with regard to training and tools.

The metric activities of Bosch Diesel Injection appear to be the type of situation that would be most helpful in our study. I would like to confirm my visit to Bosch Diesel Injection on April 23rd at 1:00 PM. I will be accompanied for the visit by Ed McEvoy, Director of Research, U.S. Metric Board. We will spend the time discussing the metric activities, and gathering data regarding the training and worker tools. I have enclosed a copy of our study methodology which outlines two cost structures dealing with training costs and tool costs, Exhibits B & C. These two sheets indicate the types of data we are trying to collect. However, I recognize that some of this data may be quite difficult to collect and thus, may not be readily available. The intent of our visit would be to gather as much data as is reasonably available, without placing an undue burden on you and your associates.

Because the study is quite limited by resources, we have been asked to focus on specific occupational categories; these are indicated in Exhibit A in the methodology. I would like to focus, to the extent possible, on the experience that Bosch Diesel Injection has with individuals working in any of these selected or associated occupations. As a starting point for the tool cost issues, we are trying to identify the individual tools owned by an employee that he is expected to have as a condition of employment. This may or may not apply to Bosch Diesel Injection. However, if such tool lists are available, they would be most helpful. We will arrive at 1:00 PM on the 23rd. Thank you very much for your cooperation, and we look forward to meeting you.

Very truly yours,
MIDDLESEX RESEARCH CENTER, INC.

Judith LeFande
Associate

EXHIBIT I (cont.)

WORKER TOOLS & TRAINING

Interview Summary

Name ______________________________ Date ______________

Title ______________________________ Consultants __________

Organization ______________________________ __________

Union ______________________________ Non Union __________

Application Area: Training ______________ Tools ______________

Secondary Issues ______________________________

Conversion: Hard ____; Soft ____; Gearing up for ________

Occupations: ______________________________ ______________________________

______________________________ ______________________________

Topics Covered (✓)

#'s Trained ___ Tools required ___

Training methods ___ Tool costs ___

Cost of training ___ Tools paid for by ___

Job time/non job time ____ ______________ ____

Summary Comments:

## COST STRUCTURES

Occupation: ______________________________

Tool list availability yes ____ no ____

Cost of replacement tools ____________________
- Employee cost ____________________
- Employer cost ____________________

Cost of duplicative tools ____________________
- Employee cost ____________________
- Employer cost ____________________

Incremental cost of maintaining both sets:
- Employee cost ____________________
- Employer cost ____________________

#'s trained ____________________

Training development cost ____________________

Training materials purchase cost ________________

Training delivery costs:
- Trainer ____________________
- Travel ____________________
- Facility ____________________
- Materials ____________________
- Lost job time ____________________
- Over time ____________________

Cost of change in productivity due to conversion ________________

Individual earnings increase or decrease due to change ________________

Cost to customer due to change ________________

EXHIBIT J

## ADDITIONAL DATA SOURCES

1980 Chevrolet Citation Shop Manual

1981 Pontiac Phoenix Service Manual

1981 Ford Escort-Lynx Car Shop Manual

Mayer, Rothkopf and CIE Training Manuals

International Harvester Corporate Metrification Policy

Allis Chalmers Metric Education Materials

Caterpillar Tractor Metric Education Materials

Signode Metric Education Materials

U.S. Steel Metric Education Materials

Shop Tools - Fleet Maintenance and Specifying Sept 1980

Canadian Assistance Program - Worker's Metric Tools

Brown & Sharpe Shop Tool Manual

Starrett Fifth Edition Catalog No. 27

Sears Craftsman Tools Catalog 1979-80

Stanley Tools Full Line Catalog 1979/1980

DoAll Tooling and Supplies - Tools for Industry

# IV. DATA ANALYSIS

This chapter of the report presents the results of data gathered during the field visits, as well as additional information analyzed during the study. The results are presented in three sections. The first section addresses tabulated results of the site visits; the next section provides an analysis of the site visits; and the final section discusses other data sources.

## A. TABULATED RESULTS

The results of the site visits have been tabulated in a variety of presentations that illustrate data collected at the sites. Each of these presentations (Exhibits K through P) focuses on a different aspect of the study. Since the sample size was not selected by using statistical techniques, the results of these tables should not be used to make statistical inferences regarding the total worker population.

### 1. Demographic Features of the Participants

Exhibit K summarizes the key demographic features of each of the 16 site visit participants. These features include geographic location, products produced or industry served, and some general indicators regarding the local economy and employment trends. Eight of the participants had formal representation by labor unions, seven of them were non-union shops, and one was a mixture. Since the participants varied in size, one feature on the exhibit indicates whether the participant was a division of a large corporation, an individual corporation, or a local business establishment. The extent to which technology provides opportunities for change in the particular industry is indicated by the technological trends entry.

### 2. Occupations Analyzed

A summary of the occupational categories employed by the participating groups is shown in Exhibit L. This exhibit provides a display of the participants versus the 20 occupational categories originally selected for the study. Six of these categories were not actually studied since no metric activity could be identified in the industries that employ workers in these occupations.

### 3. Change Strategies of the Participants

Exhibit M illustrates the various metric change strategies employed by the study participants. The attributes identified in Chapter II of this

report are listed, with a check mark indicating which of those attributes applies to each of the study participants.

4. Tool Issues

The key elements associated with tool issues are summarized in Exhibit N for each of the study participants. Four factors address tool approach; and, as can be seen in the exhibit, in most cases the employer provides metric tools at the work location. In two instances the employer provides individual metric tools for each employee. The two service center participants, Auto Service Centers and Gardiner Equipment, require the individual employee to provide his own tools. In one non-union manufacturing company, individual employees provide their own tools.

Tool cost information is difficult to obtain with any degree of accuracy; however, some cost data were collected and are also shown in Exhibit N. The typical cost for individual metric tools ranges between $100 and $200 per person for the manufacturing industries, and ranges from $500 to $1000 per person for the service industries. Additional data on tool lists and tool costs are presented in Section IV.C on Other Data Sources.

5. Training Issues

A summary of the key metric training issues is presented in Exhibit O. This exhibit outlines the approaches used by the participants in accomplishing metric training. The chart lists two groups of attributes, one addressing the development approach, and one addressing the presentation approach of the participant. In most cases, the participants took a self-development approach to the preparation of materials for metric training programs. In some instances, local technical colleges or schools were called upon to develop materials. For the most part, training programs were presented by company personnel and on company time. There are, however, some groups of participants that did not receive any formal metric training. These groups generally consist of people who work in the service industries, such as the Automotive Service Centers, Gardiner Equipment, and the marine repair industries.

6. Training Costs

Exhibit P illustrates the training cost data provided by the participants. The cost of metric training programs is very difficult to ascertain because most participants do not separate metric training programs from other ongoing training activities. However, in some cases, participants were able to provide specific cost data, including the development of some cost materials for the participants. The range of costs per person trained varies substantially, depending on the approach taken. For the four entries that have specific data, this cost ranges between $15 per person and $350 per person.

## B. ANALYSIS OF RESULTS

The results of each site visit have been documented in the summary reports which are included in Appendix IV. A summary of the analysis of the data resulting from these visits is presented in the following paragraphs.

### 1. Tool Issues

A key question with regard to individual tools was, "Who pays for metric tools, and how are they made available to the individual worker?" The results of the site visits show that in all but three cases, metric tools were provided by the employer. In one non-union manufacturing shop, and in both the automotive and heavy equipment service centers, individual employees were required to provide their own metric tools. The most common method for employers to provide tools is to make limited sets of metric tools available at the work site.

The cost of metric tools varies considerably depending on the nature of the work being performed. Experience from the study indicates that in a manufacturing environment, the cost per worker is usually less than $200. In contrast, in some of the service center occupations (such as truck maintenance), the cost for individual metric tools can run as high as $1,000 per mechanic. In jobs involving senior tool and die workers in manufacturing, individual tool costs can also run as high as $1,000 per worker.

In addition to individual tools, the study attempted to identify the cost to participating organizations for expendable tools used inside the plant, such as gauges, jigs, taps and dies, and similar items. In only one case were we able to identify these costs. In that case a manufacturer spent approximately $37,000 for expendable metric tools to accommodate a new totally metric product in its manufacturing process. Many participants considered all tooling that was part of the routine change required by new designs as being expendable, and did not maintain separate cost data for metric tooling.

### 2. Training Issues

The key elements with regard to training were the development of materials, presentation of training programs, and training costs. With respect to the development of training materials, the study shows that the predominant approach taken is self-development of training materials. Seven of the participants took this approach and developed internal corporate metric training materials. Two of the participants purchased outside materials from a commercial training organization. Three of the participants had a local technical school or college develop training materials for them.

The dominant approach to presentation of metric training programs was to have company personnel teach the program. This was done by nine of the participants in the study. Three of the participants had their training programs taught by local technical schools. Some of the participants expected employees to learn metric measurement by self-taught methods. In this case, the employer provided training booklets and materials, but the individual was required to learn in a self-instructional mode. In the automotive service centers and the tractor service center, no training materials were provided by the employer, and individuals had to learn whatever new information was necessary on their own.

Most metric training programs were provided on company time. Ten of the study participants chose this method for delivery of metric training programs. In a few cases individuals were expected to provide additional personal time beyond the company time. In most instances, courses taught on company time were taught at the place of employment in normal classroom facilities provided by the employer. In one case, workers participated in a training program sponsored by the local union and presented in the evenings at the local union hall. In two other situations, workers were required as a condition of employment to participate in a training program taught at a local technical college. This technical college training included metric measurement as part of its course of instruction. The companies whose training materials were reviewed include the following: Alcoa Aluminum; Allis Chalmers; Caterpillar Tractor; Louisiana Off-Shore Oil Port; Mayer, Rothkopf Industries; and U.S. Steel.

The study attempted to identify specific costs associated with metric training programs. These costs include the development of materials, presentation of the training program, and participation costs. The average cost per person trained ranges between $15 and $350. The higher costs were incurred when a training program required approximately ten hours of an employee's time, while the lower cost reflects only two hours of training per person. Typically, the largest element of cost associated with metric training programs was the "participation cost", which represents salaries paid to employees while they are away from work and participating in training programs. In some cases, these costs were provided as estimates by the participants; in others, they were estimated by taking an average hourly wage and applying it to the number of hours that each individual participated in metric training. In all cases where training programs have been provided, the costs were borne by either the employer or the union.

### 3. Career Issues

Each of the participants was queried regarding the various career issues that had been identified in the study. Very few examples of metric impact were identified in the course of these discussions with regard to career issues. In most cases, the effects of metric change on job rotation, job mobility, and career ladders appear to be minimal. The study did not identify any organization that utilized red circling and, thus, we were unable to measure the effect of metric change on this practice. With

respect to elderly workers, there was some indication that they experience a slightly higher level of anxiety regarding metric training programs than others workers do. However, this anxiety seems to be overcome in the course of training programs, and elderly workers do not appear to experience any difficulty in using metric measurement.

4. Companion Issues

The study team's research on companion issues focused primarily on safety factors, productivity, collective bargaining, and the use of tax deductions.

Most of the individuals who participated in the study could not identify specific incidents involving safety hazards that had occurred as a direct result of metric change. Some of the people who were interviewed did express the opinion that metric change could create safety problems in certain types of job tasks -- for example, work that involves lifting items, mixing chemicals, or using pressure in filling tires, tanks, or hydraulic systems. However, no experiential data were available on this issue.

In most cases, discussions of productivity led to the conclusion that while there might be some slight change in productivity at the time metric measurement is introduced, this change cannot be measured and does not last long enough to have an impact on the manufacturing operation. Individuals engaged in the automotive and tractor maintenance areas indicated some continuing loss of productivity as a result of having to work on hybrid units that involve both metric and inch components. This loss of productivity is associated with not knowing which wrenches to use prior to beginning to dismantle an item for repair. Again, this loss of productivity appears to be very difficult to measure and document.

The impact that metric measurement is having on collective bargaining was also examined in the course of the study. While many of the study participants are providing metric tools for workers, only a few of these arrangements are covered in formal union contracts. However, we reviewed additional union contracts that discussed the provision of metric tools by employers. Contracts reviewed include the following: Allis Chalmers Corporation West Allis Plant agreement with the International Union of United Automobile, Aerospace & Agricultural Implement Workers of America and its Local 248; Western States Trucking Maintenance Agreement with the International Association of Machinists and Aerospace Workers; and International Harvester Company Sales Operations agreement with the International Association of Machinists and Aerospace Workers. It appears from the results of this study that metric tools and metric training are not major issues in collective bargaining; and although these issues have been raised, they have been dealt with easily in the negotiating process.

With regard to the use of tax deductions, only one individual was identified in this study whose tax situation allowed him to itemize

deductions and, therefore, deduct the cost of the metric tools that were required in his work. Most of the individuals who were interviewed were not aware that itemized tax deductions could provide for some recovery of the cost of metric tools.

## C. OTHER DATA SOURCES

In addition to conducting site visits, the study team reviewed and analyzed numerous other sources of information. These sources cover a wide spectrum, including periodicals, actual metric training materials, automotive service manuals, and other sources. A complete list of these sources was provided as Exhibit J in Chapter III.

### 1. Tool Lists

The original study methodology suggested that individual tool lists for occupations would be readily available from a number of sources. In conducting the study, the team found that many tool lists exist in a very informal environment and, thus, are not readily available as printed or formalized lists. To the extent possible, we gathered these lists from a variety of sources. Some lists were established by employer-employee negotiations, and are used in the course of defining what an employee must bring to the job site. Other lists were developed by individuals compiling lists in the course of the interviews, and these can be viewed as representative lists although not necessarily formalized lists. Other lists were obtained from published materials dealing with metric conversion activities over the past two years. Each of these lists is included as Exhibit Q at the end of this chapter.

### 2. Tool Costs

To supplement the cost data gathered from the site visits, MRC attempted to develop cost data by applying tool catalogue prices to the tool lists gathered during the course of the study. These catalogue prices represent 1980 list prices from a variety of tool sources. Since each individual tool has a range of feature options available, as well as variable quality, a price range was established for each item on the list. The results of these tool prices are shown in Exhibit R. Tool costs for the lists above range from $165 to $882.

### 3. Canadian Experience

The Metric Commission Canada was contacted and cumulative data was obtained regarding the Assistance Program - Workers and Metric Tools as of September 1980. The Canadian experience is tabulated below and shows that the average claim received is less than $200 per person for tool costs.

| | Claims | Total Value | Value/Claim |
|---|---|---|---|
| Received | 25,793 | $4,965,033 | $192 |
| Approved | 21,900 | $3,797,474 | $173 |

The Canadian assistance program provides for 50% reimbursement of individual tool costs and, thus, individual tool costs in Canada appear to be between $384 and $346 per person.

EXHIBIT K

## DEMOGRAPHIC FEATURES OF STUDY PARTICIPANTS

| Study Participants | Union Representation | Non Union Shop | Industry/Products | Location | Organizational Entity | Local Economy Trends | Technological Trends | Employment Trends |
|---|---|---|---|---|---|---|---|---|
| AFL-CIO | ✓ | | UNION | 13 STATES | UNION | LAGGING | N/A | N/A |
| ALCOA ALUMINUM | ✓ | | METALS | PITTS | CORP | LAGGING | LOW | DOWN |
| ALLIS CHALMERS | ✓ | | HEAVY EQPT | MILW | DIV | STABLE | MED | STABLE |
| AUTO SERVICE CENTERS | ✓ | ✓ | AUTO MAINT. | VARIOUS | LOCAL BUS | STABLE | MED | STABLE |
| BOLAND, DIXIE & GBE | ✓ | | MARINE REPAIR | NEW ORLEANS | LOCAL BUS | STABLE | LOW | STABLE |
| CATERPILLAR TRACTOR | ✓ | | HEAVY EQPT | PEORIA | CORP | STABLE | MED | UP |
| GARDINER EQUIPMENT | | ✓ | EQPT MAINT | LA PLATA MD | LOCAL BUS | SEASONAL | MED | STABLE |
| J.I. CASE - DROTT | | ✓ | HEAVY EQUIP | WAUSAU WIS | DIV | LAGGING | LOW | DOWN |
| JOHN DEERE | ✓ | | HEAVY EQPT | MOLENE IL | CORP | STABLE | MED | STABLE |
| LOOP | | ✓ | OIL TRANS | NEW ORLEANS | CORP | STABLE | MED | UP |
| MAYER, ROTHKOPF | | ✓ | MAN. | ORANGEBURG | DIV | GROWTH | HIGH | UP |
| REGAL BELOIT | | ✓ | MAN. | SOUTH BELOIT | CORP | STABLE | MED | UP |
| ROBERT BOSCH | | ✓ | MAN. | CHARLESTON, SC | DIV | GROWTH | HIGH | UP |
| SIGNODE | | ✓ | MAN. | GLENVIEW IL | CORP | GROWTH | MED | UP |
| SUN PETROLEUM | ✓ | | OIL PROC. | TOLEDO OH | DIV | LAGGING | MED | STABLE |
| U.S. STEEL | ✓ | | METALS | PITTS PA | CORP | LAGGING | LOW | DOWN |

EXHIBIT L

## SUMMARY OF OCCUPATIONS VS PARTICIPANTS

| Study Participants | Melting, pouring, casting | Machinists and related occupations | Toolmakers and related occupations | Fabricating machine occupations | Vehicle mechanics and repairers | Aircraft mechanics and repairers * | Rail equipment mechanics and repairers * | Engine, transmission, and related mechanics | Business and commercial machine repairers | Stone cutters and carvers | Arc welders and cutters | Repair of generators, motors, and accessories | Repair of transmission lines and circuits * | Repair of wire communication equipment * | Repair of household appliances * | Carpenters and related occupations | Brick and stone masons and tile setters | Plumbers, gas fitters, steam fitters | Miscellaneous structural work occupations * | Occupations in production and distribution of gas |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AFL-CIO | | 0 | 0 | | | | | | | 0 | | | | | | 0 | 0 | 0 | | |
| ALCOA ALUMINUM | 0 | | | | | | | | | | | | | | | | | | | |
| ALLIS CHALMERS | | 0 | 0 | 0 | | | | | | | 0 | | | | | | | | | |
| AUTO SERVICE CENTERS | | | | | X0 | | | X0 | | | | | | | | | | | | |
| BOLAND, DIXIE & GBE | | 0 | 0 | | | | | 0 | | | 0 | 0 | | | | | | | | |
| CATERPILLAR TRACTOR | | 0 | 0 | 0 | | | | | | | 0 | | | | | | | | | |
| GARDINER EQUIPMENT | | | | | X | | | X | | | | | | | | | | | | |
| J.I. CASE - DROTT | | X | X | X | | | | | | | X | | | | | | | | | |
| JOHN DEERE | | 0 | 0 | 0 | | | | | | | 0 | | | | | | | | | |
| LOOP | | | | | | | | | | | | | | | | | | X | | X |
| MAYER, ROTHKOPF | | X | X | | | | | | | | | | | | | | | | | |
| REGAL BELOIT | | X | X | | | | | | | | | | | | | | | | | |
| ROBERT BOSCH | | X | X | | | | | | | | | | | | | | | | | |
| SIGNODE | | X | X | X | | | | | | | | | | | | | | | | |
| SUN PETROLEUM | | | | | | | | | | | | | | | | | | 0 | | 0 |
| U.S. STEEL | | 0 | | | | | | | | | | | | | | | | | | |

* no metric activity; 0 union employees; X non-union shop; X0 both

METRIC CHANGE STRATEGIES OF PARTICIPANTS

INDEPENDENT VARIABLES

| Study Participants | Dependency | . Very independent of others | . Highly dependent on suppliers | . Highly dependent on customers' demands | Influence | . Little power | . Can influence suppliers | . Can influence customers | Capital Equipment | . Annual retooling | . High in-plant investment | . Digital readouts available |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AFL-CIO | N/A | | | | | | | | | | | |
| ALCOA ALUMINUM | | | | ✓ | | ✓ | | | | | ✓ | |
| ALLIS CHALMERS | | | | ✓ | | | ✓ | | | | ✓ | ✓ |
| AUTO SERVICE CENTERS | | | ✓ | | | ✓ | | | | | | |
| BOLAND, DIXIE & GBE | | | | ✓ | | ✓ | | | | | | ✓ |
| CATERPILLAR TRACTOR | | ✓ | | | | | ✓ | ✓ | | | ✓ | ✓ |
| GARDINER EQUIPMENT | | | ✓ | | | ✓ | | | | | | |
| J.I. CASE - DROTT | | | | | | | ✓ | | | | ✓ | ✓ |
| JOHN DEERE | | | ✓ | | | | ✓ | | | | ✓ | ✓ |
| LOOP | | | | ✓ | | ✓ | | | | | | |
| MAYER, ROTHKOPF | | | ✓ | | | | | ✓ | | | ✓ | ✓ |
| REGAL BELOIT | | | | ✓ | | ✓ | | | | | | ✓ |
| ROBERT BOSCH | | | ✓ | | | | | ✓ | | | ✓ | ✓ |
| SIGNODE | | ✓ | | | | | | ✓ | | | ✓ | ✓ |
| SUN PETROLEUM | | | | ✓ | | ✓ | | | | | | |
| U.S. STEEL | | | | ✓ | | ✓ | | | | | ✓ | |

EXHIBIT M-2

METRIC CHANGE STRATEGIES OF PARTICIPANTS

ATTRIBUTES

| Study Participants | Use of Metric Language: . Use only SI | . Mixed use of both SI & customary | . Use only customary measurement | Use of Engineering Standards: . Use all metric standards | . Use both metric & inch standards | . Use only inch standards | Pace of Metric Change: . Corporate-wide or divisional | . Introduce metric in all new designs | . Use metric on some projects | . Resist the use of metric | Industry Position: . Leader in metric use | . Follower | . Observer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AFL-CIO | | | | | | | | | | | | | ✓ |
| ALCOA ALUMINUM | | | ✓ | | | ✓ | | | ✓ | | | ✓ | |
| ALLIS CHALMERS | | ✓ | | | ✓ | | D | | ✓ | | | ✓ | |
| AUTO SERVICE CENTERS | | | ✓ | | ✓ | | | | | | | ✓ | |
| BOLAND, DIXIE & GBE | | ✓ | | | ✓ | | | | ✓ | | | ✓ | |
| CATERPILLAR TRACTOR | ✓ | | | | ✓ | | C | ✓ | | | ✓ | | |
| GARDINER EQUIPMENT | | ✓ | | | ✓ | | | | | | | ✓ | |
| J.I. CASE - DROTT | | ✓ | | | ✓ | | D | ✓ | | | ✓ | | |
| JOHN DEERE | | ✓ | | | ✓ | | C | ✓ | | | ✓ | | |
| LOOP | ✓ | | | | ✓ | | | | ✓ | | ✓ | | |
| MAYER, ROTHKOPF | ✓ | | | ✓ | | | C | ✓ | | | ✓ | | |
| REGAL BELOIT | | ✓ | | | ✓ | | | | ✓ | | ✓ | | |
| ROBERT BOSCH | ✓ | | | ✓ | | | C | ✓ | | | ✓ | | |
| SIGNODE | ✓ | | | | ✓ | | C | ✓ | | | ✓ | | |
| SUN PETROLEUM | | | ✓ | | | ✓ | I | | ✓ | | | | ✓ |
| U.S. STEEL | | | ✓ | | | ✓ | | | ✓ | | | ✓ | |

EXHIBIT N

## SUMMARY OF TOOL ISSUES

| | TOOL APPROACH | | | | | TOOL COSTS | |
|---|---|---|---|---|---|---|---|
| Study Participants | Employer provides to individual | Employer provides at work station | Employee must provide own tools* | Covered in union contract | | Average cost per worker | Expendible tool costs |
| AFL-CIO | N/A | N/A | N/A | N/A | | N/A | N/A |
| ALCOA ALUMINUM | | | | | | | |
| ALLIS CHALMERS | | ✓ | | | | | |
| AUTO SERVICE CENTERS | | | ✓ | | | $500 to $1000 | |
| BOLAND, DIXIE & GBE | | ✓ | | | | $200 | |
| CATERPILLAR TRACTOR | ✓ | | | ✓ | | $150 | |
| GARDINER EQUIPMENT | | | ✓ | | | | |
| J.I. CASE - DROTT | | | ✓ | | | $109 | $37,000 |
| JOHN DEERE | | ✓ | | | | | |
| LOOP | ✓ | | | | | | |
| MAYER, ROTHKOPF | | ✓ | | | | | |
| REGAL BELOIT | | ✓ | | | | | |
| ROBERT BOSCH | | ✓ | | | | | |
| SIGNODE | | ✓ | | | | | |
| SUN PETROLEUM | | ✓ | | | | | |
| U.S. STEEL | | | | | | | |

* Typically only up to 3/4" or 1" sizes; N/A not applicable

EXHIBIT O

## SUMMARY OF METRIC TRAINING APPROACHES

| Study Participants | DEVELOPMENT APPROACH | | | | | | PRESENTATION APPROACH | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Self Developed | Purchased | Local Technical School/ College | Apprenticeship | Consultant | | Consultant | Company taught | Local school taught | Self taught | On company time | On personal time | Apprenticeship |
| AFL-CIO | | | | | ✓ | | ✓ | | | | | | ✓ |
| ALCOA ALUMINUM | | ✓ | | | | | | ✓ | | ✓ | ✓ | | |
| ALLIS CHALMERS | ✓ | | | | | | ✓ | ✓ | | | ✓ | ✓ | |
| AUTO SERVICE CENTERS | | | | | | | | | | ✓ | | | |
| BOLAND, DIXIE & GBE | | | | ✓ | | | | | | ✓ | | | ✓ |
| CATERPILLAR TRACTOR | ✓ | | | | | | | ✓ | | | ✓ | | |
| GARDINER EQUIPMENT | | | | | | | | | | ✓ | | | |
| J.I. CASE - DROTT | | | ✓ | | | | | | ✓ | | ✓ | ✓ | |
| JOHN DEERE | ✓ | | | | | | | ✓ | | | ✓ | | |
| LOOP | ✓ | | | | | | | ✓ | | | ✓ | | |
| MAYER, ROTHKOPF | | | ✓ | | | | | | ✓ | | | ✓ | ✓ |
| REGAL BELOIT | ✓ | | | | | | | ✓ | | | ✓ | | |
| ROBERT BOSCH | | | ✓ | | | | | | ✓ | | | ✓ | ✓ |
| SIGNODE | ✓ | | | | | | | ✓ | | | ✓ | | |
| SUN PETROLEUM | ✓ | | | | | | | ✓ | | | ✓ | | |
| U.S. STEEL | | ✓ | | | | | | ✓ | | ✓ | ✓ | | |

EXHIBIT P

## SUMMARY OF METRIC TRAINING COSTS

| Study Participants | Number of persons trained | Course length in hours | Development costs | Presentation costs | Participation costs | Total costs | Average cost per person | Borne by whom? |
|---|---|---|---|---|---|---|---|---|
| AFL-CIO | 9400 | varies | N/A | N/A | N/A | 191,720 | $20.40 | union D.Ed |
| ALCOA ALUMINUM | * | * | * | * | * | * | * | * |
| ALLIS CHALMERS | 250 | 2 | - | 3,-750 | - | 3,750 | $15 | UAW |
| AUTO SERVICE CENTERS | * | * | * | * | * | * | * | * |
| BOLAND, DIXIE & GBE | * | * | * | * | * | * | * | * |
| CATERPILLAR TRACTOR | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Co. |
| GARDINER EQUIPMENT | * | * | * | * | * | * | * | * |
| J.I. CASE - DROTT | 371 | 2-6 | 13500 | 1,080 | 22130 | 36710 | $98 | Co. |
| JOHN DEERE | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| LOOP | 24 | 2 | 500 | 283 | 600 | 1,383 | $57 | Co. |
| MAYER, ROTHKOPF | N/A | N/A | N/A | N/A | N/A | N/A | N/A | X |
| REGAL BELOIT | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| ROBERT BOSCH | N/A | N/A | N/A | N/A | N/A | N/A | N/A | X |
| SIGNODE | 314 | 10 | 5,000 | 15220 | 94500 | 99500 | $340 | Co. |
| SUN PETROLEUM | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| U.S. STEEL | * | * | * | * | * | * | * | * |

N/A not available; * no training conducted; X costs borne by third party and potential employees.

EXHIBIT Q-1

TOOL LIST COMPILED BY MACHINIST AT MAYER, ROTHKOPF INDUSTRIES

| | |
|---|---|
| * | 1" micrometer |
| * | 6" scale |
| * | combination square set |
| | angle plate |
| * | 1"-2"-3" block set |
| | 5" sine bar |
| | machinist's handbook |
| * | .001 indicator |
| * | 6" vernier calipers |
| | telescoping gauges |
| | planner gauge |
| * | radius gauges |
| * | thread tool gauge |
| | scriber |
| | dividers |
| | hammer, hard & soft |
| | C clamps |
| | pin punch set |
| | center punch |
| | adjustable wrench |
| | vise grips |
| | transfer punches |
| * | Allen wrench set |

* will require metric versions of tools

EXHIBIT Q-2

## METRIC HAND TOOLS LIST COMPILED BY CLARK EQUIPMENT

Set of 6-32 mm Standard open end wrenches consisting of:

6 & 7 mm
7 & 8 mm
8 & 10 mm
10 & 11 mm
11 & 13 mm
12 & 14 mm
13 & 15 mm
14 & 15 mm
16 & 18 mm
17 & 19 mm
18 & 21 mm
19 & 22 mm
21 & 24 mm
22 & 24 mm
24 & 27 mm
27 & 30 mm
30 & 32 mm

Set of 2-19mm "L" Shape Hexagon wrenches, consisting of:

2 mm
2.5 mm
3 mm
4 mm
5 mm
6 mm
7 mm
8 mm
9 mm
10 mm
12 mm
14 mm
17 mm
19 mm

Hexagon Head Socket Set, 6-17 mm, consisting of:

6 mm
8 mm
10 mm
12 mm
14 mm
17 mm

Nutdriver set, 4-13 mm, consisting of:

4 mm
5 mm
5.5 mm
7 mm
8 mm
10 mm
11 mm
12 mm
13 mm

Hexagon Head Socket, 4 mm, 3/8' drive

36 mm Socket

46 mm Socket

Ratchet Box Sockets, 12 & 13 mm,

17 & 19 mm, and 10 & 11 mm

Bracket Hex Wrench Set

EXHIBIT Q-3

# NATIONAL TOOL, DIE & PRECISION MACHINING ASSOCIATION

## Suggested Replacement Metric Personal Tools & Instruments For Skilled Employees in the Tooling & Machining Industry

- 0-25 mm Micrometer
- 25-50 mm Micrometer
- 150 mm Dial Caliper (or Vernier Caliper)
- 150 mm Steel Rule
- 300 mm Steel Rule
- 150 mm Flexible Rule (Optional)
- 300 mm Replacement Blade for Combination Square
- Set of Feeler Gauges
- Set of Screw Pitch Gauges
- Set of Fillet Gauges
- Test Indicator (normally required only by toolmakers)

EXHIBIT Q-4

AUTOMOBILE MECHANICS' METRIC TOOL LIST COMPILED BY
MR. VODREY SHOKES OF EAST-WEST LINCOLN MERCURY, INC. OF LANDOVER HILLS, MD

*Basic metric tools needed in addition to American Standard Tools*

1/4" drive socket sets 12 sockets 4 mm to 13 mm
3/8" drive socket sets (shallow) 16 sockets 6 mm to 22 mm
3/8" drive socket sets (deep) 11 sockets 9 mm to 19 mm
3/8" drive flex socket set 11 sockets 9mm to 19 mm
1/2" drive socket set (shallow) 12 mm to 30 mm
1/2" drive socket set (deep) 12 mm to 30 mm
1 Combination Box end - open end wrench set
    16 pieces 6 mm to 22 mm
1 Hex key set 10 pieces 1.27 mm to 10 mm
1 metric tap and die set (large)

EXHIBIT Q-5.1

# TOOL LIST FOR TRUCK MECHANICS PROVIDED BY INTERNATIONAL ASSOCIATION OF MACHINISTS AND AEROSPACE WORKERS

| DESCRIPTION |
|---|
| **1/4" DRIVE SOCKET** |
| 3/16" Single Hex Socket |
| 7/32" Single Hex Socket |
| 1/4" Single Hex Socket |
| 9/32" Single Hex Socket |
| 5/16" Single Hex Socket |
| 11/32" Single Hex Socket |
| 3/8" Single Hex Socket |
| 7/16" Single Hex Socket |
| **3/8" DRIVE SOCKET** |
| 1/4" Socket (6 point or 12 point) |
| 5/16" Socket " |
| 3/8" Socket " |
| 7/16" Socket " |
| 1/2" Socket " |
| 9/16" Socket " |
| 5/8" Socket " |
| 11/16" Socket " |
| 3/4" Socket " |
| 3/16" Socket " |
| 7/8" Socket " |
| 15/16" Socket " |
| 1" Socket " |
| 1/4" Deep Socket (6 or 12 point) |
| 5/16" Deep Socket " |
| 3/8" Deep Socket " |
| 7/16" Deep Socket " |
| 1/2" Deep Socket " |
| 9/16" Deep Socket " |
| 5/8" Deep Socket " |
| 11/16' 'Deep Socket " |
| 3/4" Deep Socket " |
| **1/2" DRIVE SOCKET** |
| 3/8" Socket (6 or 12 point) |
| 7/16" Socket " |
| 1/2" Socket " |
| 9/16" Socket " |
| 5/8" Socket " |
| 11/16" Socket " |
| 3/4" Socket " |
| 13/16" Socket " |
| 7/8" Socket " |
| 15 16" Socket " |
| 1" Socket " |
| 1-1/8" Socket " |
| 1-1/4" Socket " |

| Drive | Size mm | Points | Catalog Number | Wt. oz. | Each |
|---|---|---|---|---|---|
| *METRIC* Regular-depth | | | | | |
| 1/4 | 4 | 6 | 9 HT 43505 | 2 | $1 0[illegible] |
| 1/4 | 5 | 6 | 9 HT 43501 | 2 | 1 09 |
| 1/4 | 6 | 6 | 9 HT 43502 | 2 | 1 09 |
| 1/4 | 7 | 6 | 9 HT 43503 | 2 | 1 09 |
| 1/4 | 8 | 6 | 9 HT 43504 | 2 | 1 09 |
| 1/4 | 9 | 6 | 9 HT 4350[illegible] | 2 | 1 09 |
| 1/4 | 10 | 6 | 9 HT 43508 | 3 | 1 09 |
| 1/4 | 11 | 6 | 9 HT 43509 | 3 | 1 09 |
| 1/4 | 12 | 6 | 9 HT 43513 | 3 | 1 09 |
| 1/4 | 13 | 6 | 9 HT 43514 | 3 | 1 09 |

*METRIC*, Regular-depth

| Size | Pts | Drive | Catalog No | Wt | Each |
|---|---|---|---|---|---|
| 9mm | 6 | 3/8 | 9 HT 43541 | 3 oz | $1 79 |
| 10mm | 6 | 3/8 | 9 HT 43542 | 3 oz | 1 79 |
| 11mm | 6 | 3/8 | 9 HT 43543 | 3 oz | 1 89 |
| 12mm | 6 | 3/8 | 9 HT 43544 | 3 oz | 1 89 |
| 13mm | 6 | 3/8 | 9 HT 43545 | 3 oz | 1 89 |
| 14mm | 6 | 3/8 | 9 HT 43546 | 3 oz | 1 99 |
| 15mm | 6 | 3/8 | 9 HT 43547 | 3 oz | 1 99 |
| 17mm | 6 | 3/8 | 9 HT 43548 | 4 oz | 1 99 |
| 19mm | 6 | 3/8 | 9 HT 43549 | 4 oz | 1 99 |
| 9mm | 12 | 3/8 | 9 HT 44301 | 3 oz | 1 79 |
| 10mm | 12 | 3/8 | 9 HT 44302 | 3 oz | 1 79 |
| 11mm | 12 | 3/8 | 9 HT 44309 | 3 oz | 1 89 |
| 12mm | 12 | 3/8 | 9 HT 44303 | 3 oz | 1 89 |
| 13mm | 12 | 3/8 | 9 HT 44304 | 3 oz | 1 89 |
| 14mm | 12 | 3/8 | 9 HT 44305 | 3 oz | 1 99 |
| 15mm | 12 | 3/8 | 9 HT 44306 | 3 oz | 1 99 |
| 16mm | 12 | 3/8 | 9 HT 44311 | 3 oz | 1 99 |
| 17mm | 12 | 3/8 | 9 HT 44307 | 4 oz | 1 99 |
| 18mm | 12 | 3/8 | 9 HT 44312 | 4 oz | 1 99 |
| 19mm | 12 | 3/8 | 9 HT 44308 | 4 oz | 1 99 |

*METRIC*, Deep

| Size | Pts | Drive | Catalog No | Wt | Each |
|---|---|---|---|---|---|
| 9mm | 6 | 3/8 | 9 HT 44425 | 4 oz | $2 19 |
| 10mm | 6 | 3/8 | 9 HT 44426 | 4 oz | 2 29 |
| 11mm | 6 | 3/8 | 9 HT 44427 | 4 oz | 2 39 |
| 12mm | 6 | 3/8 | 9 HT 44428 | 4 oz | 2 59 |
| 13mm | 6 | 3/8 | 9 HT 44429 | 5 oz | 2 69 |
| 14mm | 6 | 3/8 | 9 HT 44431 | 4 oz | 2 79 |
| 15mm | 6 | 3/8 | 9 HT 44432 | 4 oz | 2 99 |
| 16mm | 6 | 3/8 | 9 HT 44433 | 5 oz | 3 09 |
| 17mm | 6 | 3/8 | 9 HT 44434 | 5 oz | 3 19 |
| 18mm | 6 | 3/8 | 9 HT 44435 | 5 oz | 3 29 |
| 19mm | 6 | 3/8 | 9 HT 44436 | 6 oz | 3 29 |
| 9mm | 12 | 3/8 | 9 HT 44413 | 4 oz | 2 19 |
| 10mm | 12 | 3/8 | 9 HT 44414 | 4 oz | 2 29 |
| 11mm | 12 | 3/8 | 9 HT 44415 | 4 oz | 2 39 |
| 12mm | 12 | 3/8 | 9 HT 44416 | 4 oz | 2 59 |
| 13mm | 12 | 3/8 | 9 HT 44417 | 6 oz | 2 69 |
| 14mm | 12 | 3/8 | 9 HT 44418 | 6 oz | 2 79 |
| 15mm | 12 | 3/8 | 9 HT 44419 | 5 oz | 2 99 |
| 16mm | 12 | 3/8 | 9 HT 444[illegible] | 5 oz | 3 09 |
| 17mm | 12 | 3/8 | 9 HT 44422 | 5 oz | 3 19 |
| 18mm | 12 | 3/8 | 9 HT 44423 | 5 oz | 3 29 |
| 19mm | 12 | 3/8 | 9 HT 44424 | 6 oz | 3 29 |

## *METRIC*
## Regular-depth Sockets

| mm | Pts | Drive | Catalog Number | Wt oz | Each |
|---|---|---|---|---|---|
| 9 | 6 | 1/2 | 9 HT 44251 | 4 | $1 99 |
| 10 | 6 | 1/2 | 9 HT 44252 | 4 | 1 99 |
| 11 | 6 | 1/2 | 9 HT 44253 | 4 | 2 09 |
| 12 | 6 | 1/2 | 9 HT 44254 | 4 | 2 09 |
| 13 | 6 | 1/2 | 9 HT 44255 | 4 | 2 19 |
| 14 | 6 | 1/2 | 9 HT 44[illegible] | 4 | 2 19 |
| 15 | 6 | 1/2 | 9 HT 44[illegible] | 4 | 2 19 |
| 17 | 6 | 1/2 | 9 HT 44258 | 4 | 2 39 |
| 19 | 6 | 1/2 | 9 HT 44259 | 5 | 2 49 |
| 22 | 6 | 1/2 | 9 HT 44265 | 6 | 2 69 |
| 9 | 12 | 1/2 | 9 HT 44[illegible] | 4 | 1 99 |
| 10 | 12 | 1/2 | 9 HT 44[illegible] | 4 | 1 99 |
| 11 | 12 | 1/2 | 9 HT 44[illegible] | 4 | 2 09 |
| 12 | 12 | 1/2 | 9 HT 4423[illegible] | 4 | 2 09 |
| 13 | 12 | 1/2 | 9 HT 44[illegible] | 4 | 2 19 |
| 14 | 12 | 1/2 | 9 HT 44[illegible] | 4 | [illegible] |
| 15 | 12 | 1/2 | 9 HT 44[illegible] | 4 | 2 19 |
| 16 | 12 | 1/2 | 9 HT 44[illegible] | 4 | 2 39 |
| 17 | 12 | 1/2 | 9 HT 44[illegible] | 4 | 2 39 |
| 18 | 12 | 1/2 | 9 HT 44[illegible] | 5 | 2 39 |
| 19 | 12 | 1/2 | 9 HT 44[illegible]38 | 5 | 2 49 |
| 21 | 12 | 1/2 | 9 HT 44[illegible] | 6 | 2 59 |
| 22 | 12 | 1/2 | [illegible] | [illegible] | [illegible] |
| 24 | 12 | 1/2 | [illegible] | 6 | 3 [illegible] |
| 27 | 12 | 1/2 | 9 HT 44[illegible] | [illegible] | 3 39 |
| 30 | 12 | 1/2 | 9 HT 44[illegible] | [illegible] | [illegible] |
| 32 | 12 | 1/2 | 9 HT 44[illegible] | 10 | 3 [illegible] |
| 36 | [illegible] | 1/2 | 9 HT 44[illegible] | [illegible] | 4 [illegible] |

EXHIBIT Q-5.2

TOOL LIST FOR TRUCK MECHANICS PROVIDED BY
INTERNATIONAL ASSOCIATION OF MACHINISTS AND AEROSPACE WORKERS
(continued)

| DESCRIPTION |
|---|
| **1/4" DRIVE SOCKET** |
| 1/2" Single Hex Socket |
| Universal Joint—1/4" Drive |
| 2" Extension—1/4" |
| 3" Extension—1/4" |
| Ratchet—1/4" Drive |
| Nut Spinner handle—1/4" Drive |
| Metal Box (for 1/4" Drive Set) |
| |
| **3/8" DRIVE SOCKET** |
| 13/16" Deep Socket (6 or 12 point) |
| 7/8" Deep Socket " |
| 15/16" Deep Socket " |
| 1" Deep Socket " |
| 3/8" U Jt. Socket 3/8" Drive (6 or 12 pt. |
| 7/16" " |
| 1/2" " |
| 9/16" " |
| 5/8" " |
| 11/16" " |
| 3/4" " |
| Universal Joint—3/8" Drive |
| Speed Handle—3/8" Drive |
| Nut Spinner—3/8" Drive |
| Ratchet—3/8" Drive |
| 1-1/2" Extension—3/8" Drive |
| 3" " |
| 4" " |
| 6" " |
| 8" " |
| 12" " |
| Spark Plug Socket 3/8" Drive |
| **1/2" DRIVE SOCKET** |
| 1-3/8" Socket (6 or 12 point) |
| 1-7/16" Socket " |
| 1-1/2" Socket " |
| 3/8" Deep Socket " |
| 7/16" Deep Socket " |
| 1/2" Deep Socket " |
| 9/16" Deep Socket " |
| 5/8" Deep Socket " |
| 11/16" Deep Socket " |
| 3/4" Deep Socket " |
| 11/16" Deep Socket " |
| 7/8" Deep Socket " |
| 15/16" Deep Socket " |

Individual *METRIC*
Flexible Sockets
ORDERING INFO: See warranty and construction features [illegible]

| Size | Pts | Drive | [illegible] | [illegible] | Each |
|---|---|---|---|---|---|
| 10mm | 6 | 3/8 | 9 HT 42[illegible] | 4 oz | $4.9[illegible] |
| 11mm | 6 | 3/8 | 9 HT 422[illegible] | 4 oz | 4.9[illegible] |
| 12mm | 6 | 3/8 | 9 HT 42[illegible] | 4 oz | 4.9[illegible] |
| 13mm | 6 | 3/8 | 9 HT 42[illegible] | 4 oz | 4.9[illegible] |
| 14mm | 6 | 3/8 | 9 HT 42[illegible] | 4 oz | 4.9[illegible] |
| 15mm | 6 | 3/8 | 9 HT 42[illegible] | 4 oz | 4.9[illegible] |
| 16mm | 6 | 3/8 | 9 HT 42[illegible] | 4 oz | 4.9[illegible] |
| 17mm | 6 | 3/8 | 9 HT 42[illegible] | 4 oz | 4.9[illegible] |
| 18mm | 6 | 3/8 | 9 HT 42277 | 4 oz | 4.9[illegible] |
| 19mm | 6 | 3/8 | 9 HT 42278 | 4 oz | 4.9[illegible] |

*METRIC* Deep Sockets

ORDER INFO: See construction features and warranty above

| mm | Pts | Drive | [illegible] | [illegible] | Each |
|---|---|---|---|---|---|
| 14 | 12 | 1/2 | 9 HT 444[illegible] | 6 | $3.49 |
| [illegible] | 12 | 1/2 | 9 HT 44445 | [illegible] | 3.59 |
| 19 | 12 | 1/2 | 9 HT 44446 | [illegible] | 3.69 |
| 21 | 12 | 1/2 | 9 HT 44447 | 9 | 3.79 |
| 22 | 12 | 1/2 | 9 HT 44448 | 8 | 3.89 |
| 27 | 12 | 1/2 | 9 HT 44449 | 11 | 4.[illegible]9 |

TOOL LIST FOR TRUCK MECHANICS
PROVIDED BY
INTERNATIONAL ASSOCIATION OF
MACHINISTS AND AEROSPACE WORKERS
(continued)

| DESCRIPTION |
|---|
| **1/2" DRIVE SOCKET** |
| 1" Deep Socket (6 or 12 point) |
| 1-1/16" Deep Socket " |
| 1-1/8" Deep Socket " |
| 1-1/4" Deep Socket " |
| 9/16" Universal Joint Socket |
| 5/8" " |
| 11/16" " |
| 3/4" " |
| 13/16" " |
| 7/8" " |
| 15/16" " |
| **IGNITION OPEN END WRENCH** |
| 15/64" 15°-16° Open End Wrench |
| 1/4" " |
| 9/32" " |
| **COMBINATION WRENCHES** |
| 3/8" Combination Wrench |
| 7/16" " |
| 1/2" " |
| 9/16" " |
| 5/8" " |
| 11/16" " |
| 3/4" " |
| 13/16" " |
| 7/8" " |
| **OPEN END WRENCHES** |
| 1/4 - 5/16" 15° Open End Wrench |
| 5/16" - 3/8" |
| 3/8" - 7/16" |
| 7/16" - 1/2" |
| 1/2" - 9/16" |
| 9/16" - 5/8" |
| 5/8" - 11/16" |
| 11/16" - 3/4" |
| **FLAT CHISELS** |
| 1/2" Flat Chisel |
| 5/8" Flat Chisel |
| 3/4" Flat Chisel |
| **STARTER PUNCH** |
| 3/32" Starter Punch |
| 1/8" Starter Punch |
| 3/16" Starter Punch |
| **PINCH BARS** |
| 5/8" Pinch Bar |
| 3/4" Pinch Bar |

**Ignition Wrench Sets**
***METRIC***
Metric 4.5x5, 5.5x6, 6x7, 8x9mm.

***METRIC* Combination Wrenches**
[illegible]O See constr., warranty on opp. page.

| Size | Length | Catalog Number | Ship wt. | Each |
|---|---|---|---|---|
| 6mm | $3\frac{3}{16}$ in. | 9 HT 42909 | 3 oz. | $2.39 |
| 7mm | $3\frac{3}{16}$ in. | 9 HT 429[illegible] | 3 oz. | 2.49 |
| 8mm | $4\frac{1}{8}$ in. | 9 HT 42912 | 3 oz. | 2.59 |
| 9mm | $4\frac{3}{8}$ in. | 9 HT 42913 | 3 oz. | 2.59 |
| 10mm | $4\frac{3}{4}$ in. | 9 HT 42914 | 3 oz. | 2.69 |
| 11mm | $5\frac{3}{8}$ in. | 9 HT 42915 | 4 oz. | 2.79 |
| 12mm | $5\frac{7}{8}$ in. | 9 HT 42916 | 4 oz. | 2.99 |
| 13mm | $6\frac{1}{16}$ in. | 9 HT 42917 | 5 oz. | 3.09 |
| 14mm | $6\frac{7}{8}$ in. | 9 HT 42918 | 5 oz. | 3.19 |
| 15mm | $7\frac{13}{16}$ in. | 9 HT 42919 | 7 oz. | 3.29 |

***METRIC* Open-end Wrenches**

| Size | Length | Catalog No | Ship wt. | Each |
|---|---|---|---|---|
| 6x8mm | $4\frac{1}{2}$ in. | 9 HT 44502 | 3 oz. | $2.39 |
| 7x9mm | 5 in. | 9 HT 44503 | 4 oz. | 2.59 |
| 10x11mm | $5\frac{3}{16}$ in. | 9 HT 44504 | 4 oz. | 2.79 |
| 12x14mm | $6\frac{3}{16}$ in. | 9 HT 44506 | 7 oz. | 2.99 |
| 13x15mm | 7 in. | 9 HT 44507 | 6 oz. | 3.29 |
| 16x18mm | $7\frac{3}{8}$ in. | 9 HT 44521 | 7 oz. | 3.59 |
| 17x19mm | $8\frac{11}{16}$ in. | 9 HT 44508 | 8 oz. | 3.89 |
| 20x22mm | $9\frac{1}{2}$ in. | 9 HT 44522 | 11 oz. | 4.49 |
| 21x23mm | $10\frac{3}{16}$ in. | 9 HT 44523 | 15 oz. | 4.99 |
| 22x24mm | $10\frac{3}{16}$ in. | 9 HT 44509 | 13 oz. | 5.59 |
| 24x26mm | $11\frac{1}{8}$ in. | 9 HT 44515 | 1 lb. | 6.19 |
| 25x27mm | $11\frac{7}{8}$ in. | 9 HT 44516 | 1 lb. 2 oz. | 6.99 |
| 28x30mm | $12\frac{11}{16}$ in. | 9 HT 44518 | 1 lb. 5 oz. | 10.99 |
| 30x32mm | $13\frac{1}{8}$ in. | 9 HT 44519 | 1 lb. 11 oz. | 12.99 |

TOOL LIST FOR TRUCK MECHANICS
PROVIDED BY
INTERNATIONAL ASSOCIATION OF
MACHINISTS AND AEROSPACE WORKERS
(continued)

| DESCRIPTION |
|---|
| **1/2" DRIVE SOCKET** |
| Universal Joint 1/2" Drive |
| Ratchet 10" " |
| Ratchet 15" " |
| Nut Spinner 18" " |
| Speed Handle " |
| Drag Link Adjuster " |
| 2" Extension " |
| 3-1/2" Extension " |
| 5" Extension " |
| 10" Extension " |
| **IGNITION OPEN END WRENCH** |
| 5/16" Open End Wrench |
| 11/32" " |
| Ignition and Spark Plug Feeler Gauge |
| **COMBINATION WRENCHES** |
| 5/16" Combination Wrench |
| 1" " |
| 1-1/16" " |
| 1-1/8" " |
| 1-1/4" " |
| 1-5/16" " |
| 1-3/8" " |
| 1-7/16" " |
| 1-1/2" " |
| **OPEN END WRENCHES** |
| 3/4" - 13/16" 15° Open End Wrench |
| 3/4" - 7/8" " |
| 7/8" - 15/16" " |
| 15/16" - 1" " |
| 1" - 1-1/8" " |
| 1-1/16" - 1-1/8" " |
| 1-1/4" - 1-3/8" " |
| 1-3/8" - 1-1/2" " |
| **FLAT CHISELS** |
| 7/8" Flat Chisel |
| 1/8" Center Punch |
| 3/16" Center Punch |
| **STARTER PUNCH** |
| 1/4" Starter Punch |
| 5/16" Starter Punch |
| **PINCH BARS** |
| 1" Pinch Bar |
| 16" Pry Bar |

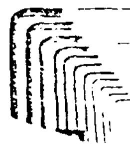
Metric 5, 5.5, 6, 7, 8, 9, 10, 11mm.

| | | | | |
|---|---|---|---|---|
| 16mm | 8 in. | 9 HT 42924 | 7 oz. | 3 39 |
| 17mm | 8 13/16 in. | 9 HT 42929 | 7 oz. | 3 59 |
| 18mm | 8 13/16 in. | 9 HT 42925 | 8 oz. | 3 79 |
| 19mm | 9 1/2 in. | 9 HT 42921 | 9 oz | 3 99 |
| 20mm | 10 1/4 in. | 9 HT 42937 | 11 oz. | 4 39 |
| 21mm | 10 7/8 in. | 9 HT 42938 | 13 oz. | 4 79 |
| 22mm | 11 7/16 in. | 9 HT 42922 | 11 oz. | 5 19 |
| 23mm | 12 1/8 in. | 9 HT 42939 | 15 oz. | 5 59 |
| 24mm | 12 1/4 in. | 9 HT 42923 | 14 oz | 5 99 |
| 25mm | 13 1/2 in. | 9 HT 42931 | 1 lb 2 oz | 6 49 |
| 26mm | 14 1/16 in. | 9 HT 42932 | 1 lb. 4 oz | 7 99 |
| 27mm | 14 3/8 in. | 9 HT 42933 | 1 lb. 7 oz. | 8 99 |
| 28mm | 15 9/16 in. | 9 HT 42934 | 1 lb 10 oz | 9 99 |
| 30mm | 16 1/4 in. | 9 HT 42935 | 1 lb. 11 oz. | 10 99 |
| 32mm | 16 7/8 in. | 9 HT 42936 | 1 lb 13 oz | 11 99 |

EXHIBIT Q-5.5

TOOL LIST FOR TRUCK MECHANICS PROVIDED BY
INTERNATIONAL ASSOCIATION OF MACHINISTS AND AEROSPACE WORKERS
(continued)

| DESCRIPTION | DESCRIPTION |
| --- | --- |
| HEX HEAD WRENCH (ALLEN) | HEX HEAD WRENCH (ALLEN) |
| ·/64" Hex Head Wrench | 3/16" Hex Head Wrench |
| /16" " | 7/32" " |
| ·/64" " | 1/4" " |
| ·/32" " | 5/16" " |
| ·/64" " | 3/8" " |
| /8" " | 7/16" " |
| ·/64" " | 1/2" " |
| ·/32" " | |
| PHILLIPS DRIVERS | PHILLIPS DRIVERS |
| # 1 Phillips Driver | # 3 Phillips Driver |
| # 2 Phillips Driver | # 4 Phillips Driver |
| STANDARD SCREW DRIVER | STANDARD SCREW DRIVER |
| 3/16" Screw Driver | 3/8" Screw Driver |
| 1/4" Screw Driver | 7/16" Screw Driver |
| 5/16" Screw Driver | |
| PLIERS | PLIERS |
| Gripping or Water Pump Type Plier | 6" Diagonal Cutter |
| 5-1/2" Standard Plier | 6" Needle Nose Plier |
| 8" Standard Plier | Battery Plier |
| 7" Lineman Plier | |
| HAMMER | HAMMER |
| 1/2 lb. Plastic Lip | 8 oz. Ball Peen |
| 1 lb. Plastic Lip | 1 lb. Ball Peen |
| 2 oz. Ball Peen | 2 lb. Ball Peen |
| 4 oz. Ball Peen | |
| MISCELLANEOUS | MISCELLANEOUS |
| Carbon Scraper | Feeler Gauge—General Use |
| Hack Saw Frame | Tool Chest |
| Magnetic Pick-up Tool | Cabinet with Casters |



*METRIC Set*
SHORT-ARM SIZES 1.5, 2, 2.5, 3, 4, 4.5, 5, 5.5, 6, 7, 8mm
LONG-ARM SIZES 1.5, 2, 2.5, 3, 4, 4.5, 5, 5.5, 6mm
ORDERING INFORMATION
Warranty, opposite page.
9 HT 46677—Wt. 11 oz. Set $4.89

EXHIBIT Q-5.6

TOOL LIST FOR TRUCK MECHANICS PROVIDED BY
INTERNATIONAL ASSOCIATION OF MACHINISTS AND AEROSPACE WORKERS
(continued)

***METRIC* Drain Plug Wrenches**

SIZES ORDERING INFO

17mm Drain Plug Wrench
Shpg. wt. 1 lb. 1 oz.
9 HT 46666 . . . $4 19

12mm Drain Plug Wrench
9 HT 46667—Wt. 7 oz. . . . $3 69

***METRIC* Nut Drivers**

| Size mm | Catalog Number | Wt. oz | Price Each |
|---|---|---|---|
| 5 | 9 HT 41981 | 5 | $2 69 |
| 6 | 9 HT 41982 | 5 | 2 69 |
| 7 | 9 HT 419[illegible] | 5 | 2 69 |
| 8 | 9 HT 41984 | 5 | 2 69 |
| 9 | 9 HT 41985 | 5 | 2 69 |
| 10 | 9 HT 41986 | 6 | 2 69 |
| 11 | 9 HT 41987 | 6 | 2.69 |

**Individual *METRIC* Box-end Wrenches**

SIZES ORDERING INFO See warranty below.

| Size | Length | Catalog No. | Shpg. wt. | Each |
|---|---|---|---|---|
| 6 x 8mm | 7 in | 9 HT 42952 | 3 oz | $2 99 |
| 7 x 9mm | 7¾ in | 9 HT 42953 | 4 oz | 3 29 |
| 10 x 11mm | 7[illegible] in | 9 HT 42954 | 4 oz | 3 59 |
| 12 x 14mm | 9[illegible] in | 9 HT 42956 | 5 oz | 3 89 |
| 13 x 15mm | 9[illegible] in | 9 HT 42957 | 6 oz | 4 19 |
| 16 x 18mm | 10[illegible] in | 9 HT 42961 | 8 oz | 4 49 |
| 17 x 19mm | 11[illegible] in | 9 HT 42958 | 7 oz | 4 79 |
| 20 x 22mm | 11[illegible] in | 9 HT 42965 | 13 oz | 5 19 |
| 21 x 2[illegible]mm | 12[illegible] in | 9 HT 429[illegible] | 14 oz | 5 49 |
| 22 x 24mm | 13[illegible] in | 9 HT 429[illegible] | 10 oz | 5 99 |
| 24 x 26mm | 14[illegible] in | 9 HT 44[illegible] | 15 oz | 6 49 |
| 25 x 28mm | 14[illegible] in | 9 HT 44[illegible]3 | 1 lb 4 oz | 7 49 |
| 27 x 30mm | 15[illegible] in | 9 HT 44[illegible] | 1 lb 4 oz | 8 49 |
| 28 x 32mm | 16[illegible] in | 9 HT 44[illegible]6 | 1 lb 7 oz | 9 99 |
| 30 x 32mm | 17 in | 9 HT 44567 | 1 lb 12 oz | 11 99 |

***METRIC* Wrenches**

DF[illegible]

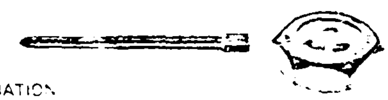
[illegible]

| Size (mm) | Length (in.) | Catalog Number | Wt. oz | Each |
|---|---|---|---|---|
| 6 x 8 | 4¾ | 9 HT 43691 | 5 | $3 29 |
| 10 x 11 | 6[illegible] | 9 HT 43692 | 7 | 3 89 |
| 12 x 13 | 7[illegible] | 9 HT 43693 | 8 | 4 79 |
| 14 x 16 | 8[illegible] | 9 HT 43694 | 11 | 5 09 |
| 17 x 19 | 10 | 9 HT 43695 | 15 | 5 49 |

***METRIC* Flare-nut Wrenches**

| Size | Length | Catalog Number | Shpg. wt. | Price |
|---|---|---|---|---|
| 9 x 11mm | 6 in | 9 HT 44175 | 4 oz | $4 49 |
| 10 x 12mm | 6½ in | 9 HT 44176 | 5 oz | 4 59 |
| 13 x 14mm | 7 in | 9 HT 44177 | 5 oz | 4 89 |
| 15 x 17mm | 7½ in | 9 HT 44178 | 8 oz | [illegible] 19 |
| 19 x 21mm | 8 in | 9 HT 44179 | 9 oz | 5 69 |

***METRIC*-size Taps and Hex Dies**



SIZES, TYPES, ORDERING INFORMATION

| Taps (mm) | Catalog No. | Wt. | Ea. | Hex Dies: Die Diam. | (mm) | Catalog No. | Wt. | Ea. |
|---|---|---|---|---|---|---|---|---|
| 3 x .50 | 9HT52031 | 2 oz | 89c | 1 in | 3 x .50 | 9HT52011 | 3 oz | $1 29 |
| 3 x .60 | 9HT52032 | 2 oz | 89c | 1 in | 3 x .60 | 9HT52012 | 3 oz | 1 29 |
| 4 x .70 | 9HT52033 | 2 oz | 89c | 1 in | 4 x .70 | 9HT52013 | 3 oz | 1 29 |
| 4 x .75 | 9HT52034 | 2 oz | 89c | 1 in | 4 x .75 | 9HT52014 | 3 oz | 1 29 |
| 5 x .80 | 9HT52035 | 2 oz | 89c | 1 in | 5 x .80 | 9HT52015 | 3 oz | 1 29 |
| 5 x .90 | 9HT52036 | 2 oz | 89c | 1 in | 5 x .90 | 9HT52016 | 3 oz | 1 29 |
| 6 x 1.00 | 9HT52037 | 2 oz | $1 09 | 1 in | 6 x 1.00 | 9HT52017 | 3 oz | 1 29 |
| 6.3 x 1.00 | 9HT52051 | 4 oz | 1 19 | 1 in | 6.3 x 1.00 | 9HT52082 | 3 oz | 1 29 |
| 7 x 1.00 | 9HT52038 | 3 oz | 1 19 | 1 in | 7 x 1.00 | 9HT52018 | 3 oz | 1 29 |
| 8 x 1.25 | 9HT52039 | 3 oz | 1.39 | 1 in | 8 x 1.25 | 9HT52019 | 3 oz | 1.29 |
| 9 x 1.00 | 9HT52041 | 3 oz | 1 49 | 1 in | 9 x 1.00 | 9HT52021 | 3 oz | 1 29 |
| 9 x 1.25 | 9HT52042 | 3 oz | 1 49 | 1 in | 9 x 1.25 | 9HT52022 | 3 oz | 1 29 |
| 10 x 1.00 | 9HT52081 | 3 oz | 1 69 | 1 in | 10 x 1.25 | 9HT52023 | 3 oz | 1 29 |
| 10 x 1.25 | 9HT52043 | 3 oz | 1.69 | 1 in | 10 x 1.50 | 9HT52024 | 3 oz | 1 29 |
| 10 x 1.50 | 9HT52044 | 3 oz | 1 69 | 1 in | 11 x 1.50 | 9HT52025 | 3 oz | 1.29 |
| 11 x 1.50 | 9HT52045 | 3 oz | 1.89 | 1 in | ⅛ x 28† | 9HT52028 | 3 oz | 1 29 |
| ⅛ x 28* | 9HT52048 | 3 oz | 1 89 | 1 in | 12 x 1.50 | 9HT52026 | 3 oz | 1 29 |
| 12 x 1.50 | 9HT52046 | 3 oz | 2 19 | 1 in | 12 x 1.75 | 9HT52027 | 3 oz | 1 29 |
| 12 x 1.75 | 9HT52047 | 3 oz | 2 19 | 1[illegible] in | 12 x 1.50 | 9HT52071 | 5 oz | 4 39 |
| 14 x 1.25 | 9HT52061 | 4 oz | 2 69 | 1[illegible] in | 12 x 1.75 | 9HT52072 | 5 oz | 4.39 |
| 14 x 2.00 | 9HT52062 | 4 oz | 2.69 | 1[illegible] in | 14 x 1.25 | 9HT52073 | 5 oz | 4 39 |
| 16 x 1.50 | 9HT52063 | 5 oz | 3 09 | 1[illegible] in | 14 x 2.00 | 9HT52074 | 5 oz | 4 39 |
| 16 x 2.00 | 9HT52064 | 5 oz | 3 09 | 1[illegible] in | 16 x 1.50 | 9HT52075 | 5 oz | 4 39 |
| 18 x 1.50 | 9HT52065 | 7 oz | 3 89 | 1[illegible] in | 16 x 2.00 | 9HT52076 | 5 oz | 4 39 |
| 18 x 2.50 | 9HT52066 | 7 oz | 3 89 | 1[illegible] in | 18 x 1.50 | 9HT52077 | 5 oz | 4 39 |
| ¼ x 19* | 9HT52067 | 4 oz | 2.29 | 1[illegible] in | 18 x 2.50 | 9HT52078 | 5 oz | 4 39 |
| . . . . | . . . . | | . . . . | 1[illegible] in | ¼ x 19† | 9HT52079 | 5 oz | 4 39 |

*British Standard thread pipe tap †British Standard thread pipe die

EXHIBIT R

## TOOL COSTS

| LIST | COST ESTIMATE |
|---|---|
| Tool list compiled by machinist at Mayer, Rothkopf Industries | $882 (1) |
| Metric hand tools list compiled by Clark Equipment | $164 (2) |
| Tool list compiled by National Tool, Die & Precision Machining Association | $458 (1) |
| Automobile mechanics' metric tool list compiled by Mr. Vodrey Shokes of East-West Lincoln Mercury, Inc. of Landover Hills, MD | $365 (2) |
| Tool list for truck mechanics provided by International Association of Machinists and Aerospace Workers | $635 (2) |

(1) Costs from Brown & Sharp Tool Manual

(2) Costs from Sears & Roebuck Catalogue

# V. STUDY FINDINGS AND CONCLUSIONS

This chapter of our report summarizes the findings and conclusions developed from MRC's analysis of the data gathered throughout the study. Consistent with the requirements outlined in the Statement of Work, the findings and conclusions emphasize tool, training, and companion issues.

The findings and conclusions presented in this chapter do not represent a statistically valid sample of the worker population within the United States or within individual industries. The limited resources available to perform this study led to the development of a study methodology that involved collecting representative data from which certain conclusions could be drawn. However, the data presented in Chapter IV should not be used to make statistical inferences regarding the general population.

## A. TOOL ISSUES

The major questions to be addressed regarding tool issues were: What is the cost of personal tools? Who pays for the provision of these tools? What is the general impact of metric conversion on an individual's tools?

### 1. Individual Tool Costs Vary Considerably

Based on the data collected, the cost for individual or personal tools can vary between $100 and $1,000 per employee, depending upon the specific nature of the occupation and the quality of the tools purchased. Generally speaking, tool costs are much lower for workers engaged in the production or manufacturing industries than for workers employed in senior tool and die making positions or in the vehicle service industries. These costs were verified by compiling representative tool lists and pricing individual tools, as well as by interviewing employees who use and/or purchase metric tools.

### 2. Often the Employer Pays for Metric Tools

In the occupational areas that were studied during this effort, it was found that employers generally provide metric tools to their workers. Some firms purchase the tools and then give them to the workers; other companies issue the necessary tools at the work site. The rationale for this approach varied by industry and location. A number of companies were disturbed by the potential problems of negotiating tool costs and agreed to provide individual worker tools early in their metric planning processes. Other firms, particularly overseas companies investing in the United

States, have always provided worker tools and, thus, routinely provided metric tools in the course of establishing U.S. operations. Some U.S. industries (for example, the petroleum industry) have also traditionally provided worker tools, and at least one such company continued this practice after converting their operations to the metric system. A total of 12 firms visited provide metric tools to workers.

### 3. Some Employees Must Pay for All of Their Own Metric Tools

During the site visits, the team identified some work situations in which individual employees assumed total responsibility for their own metric tools. This was true for one manufacturing operation and also throughout the automotive service industry. In these two cases, the tool costs varied substantially; that is, production workers were only required to spend between \$100 and \$200 per person, while the automotive service employee could spend between \$600 and \$800 to acquire a complete set of metric tools.

### 4. Tax Deductions Are Not Utilized

Many individuals who had purchased their own metric tools did not appear to be knowledgeable about the tax deductions available to them. Under current income tax regulations, individuals who itemize deductions can deduct the cost of tools that are required for employment if that expense is not reimbursed by their employer. Thus, this tax deduction is available to workers who have to buy their own metric tools and are in an income category that allows them to itemize their deductions on the Federal tax forms. This tax deduction is not available to people who do not itemize or whose metric tools are provided by the company. In the course of our interviews, we could only identify one individual who had taken advantage of this particular income tax deduction.

### 5. Individual Tools Are Purchased Incrementally

Workers who buy their own metric tools typically purchase such tools incrementally over a number of years. They will usually begin by buying the basic necessities that are essential to the performance of their jobs when the first incidence of metric measurement occurs. Then, over a period of years, they purchase additional metric tools as required, or as metric usage increases in their particular work environment. Thus, it appears that no individual is faced with the prospect of a major outlay of \$500 to \$800 for metric tools in one large purchase. This pattern of incrementally purchasing tools is consistent with the general approach that most workers take of gradually building up the "tools of the trade", whether they be customary sizes or metric tools.

### 6. Purchasing Methods Vary Considerably

The methods used by individuals to purchase personal tools vary considerably, depending upon the occupation, employment situation, and habits of the individual. Some workers purchase individual tools through a variety of suppliers; e.g., Sears, Stanley Tools, and similar tool suppliers. Other workers purchase tools from mobile tool specialists (such as Snap-On Tools) who offer convenience and provide high quality, but high cost, tools at the job site. Still others have the opportunity to buy tools at discount prices through group purchasing arrangements made by their employer or their union. Thus, the mechanism by which individuals purchase tools, as well as the price for an individual tool, varies considerably. The price is a function of the general quality of the tools purchased, the distribution mechanism, and the availability of discounts achieved through group purchases.

## B. TRAINING ISSUES

A primary objective of the study was to identify how metric training is delivered, the cost of metric training, and who bears the cost of this training. Specific conclusions are discussed in the following paragraphs.

### 1. *The Cost of Training Varies Considerably*

Because of the variety of approaches taken in developing and presenting metric training programs, the cost varies substantially. In some situations, metric training is merely added on to an existing training program. In other environments, major efforts have been made to provide extensive metric training to all employees. Some companies have purchased training materials at a relatively low cost, while others have undertaken substantial development efforts of their own or in conjunction with local technical institutes. The study found that the costs per employee trained ranged from $15 to $350 per person, depending on the approach used.

### 2. Usually the Employer Pays for Metric Training

In those cases where formal metric training programs were established, the employer paid for the development or purchase of the training materials and provided an instructor. In general, the training was conducted on company time, and the employees were paid their normal wages while attending classes. In one union manufacturing shop, the employees attended metric courses on their own time. However, the union paid for all of the direct costs associated with the training. In two firms, broad technical training was a prerequisite for hiring and was provided by a local technical college. This training includes metric measurement topics and is paid for by the participant.

3. The Length of Metric Training Programs Varies Substantially

The number of hours of metric training necessary for an individual worker varied between two hours per person and 20 hours per person, depending on the attitude of the employer, the extent of metric usage, and the nature of the occupations involved. Some organizations developed comprehensive metric training programs and provided them to all employees. Others have adopted a modular approach that focuses on the specific metric training requirements of individual occupations; this approach frequently reduces the content of the metric training program to two hours or less per person.

4. Employees Often Experience Anxiety Prior to Metric Training Programs

Workers often experience some anxiety, caused by the normal "fear of the unknown", prior to attending metric training programs. Their primary concerns were whether tests would be administered during the training program and how their lack of understanding of metric measurement would impact their jobs. In every instance encountered, this anxiety had been eliminated by the time the training program was completed and the individual employees had adapted easily to the use of metric measurement. Some of the workers who were interviewed expressed a dislike of metric measurement, but they readily admitted that using metric measurement had not impacted the quality of their work or their productivity.

5. Some Employees Receive No Formal Metric Training

In the course of our study, we found two groups of employees that did not receive any formal metric training. One group consisted of marine repair and maintenance personnel who worked for companies that had been using metric measurement to service foreign ships for over 20 years. The local vocational schools teach metric, and individual workers are expected to learn to work with it through on-the-job experience. Automotive service mechanics comprise the second major group that does not seem to receive any formal metric training. These individuals must deal with a hybrid product that consists of both metric and inch parts and fasteners. They receive no training support in dealing with metric measurement. The automotive service mechanics expressed a high level of frustration over not being able to readily identify metric fasteners from inch fasteners in the course of their normal work tasks. This issue will be covered in more depth under the companion issue of productivity.

6. Considerable Duplication of Effort Exists

Most of the organizations interviewed for this study expressed some frustration at not being able to readily identify a source of metric training materials. This has led many organizations to develop their own metric training programs or materials and, thus, "reinvent the wheel". Some

organizations have purchased materials from commercial training organizations and then modified them to suit in-house requirements. The level of duplication in terms of creating or modifying metric training materials is very high. This duplication of effort exists among technical schools, educators, trade associations, and industry trainers.

## C. CAREER ISSUES

The study examined a variety of issues that are associated with workers' careers. In general, the study found that workers' careers are not inpacted by the change to metric.

### 1. Metric Change Does Not Impact Career Issues

A variety of techniques have been utilized to expand and enhance career paths for workers. These include job enrichment, job rotation, use of formalized career ladders, and similar techniques. At the sites that were visited by the study team, the availability of training programs addressing the use of metric measurement seemed to offset any potential problems associated with career issues. Individuals who worked on metric projects seemed to be able to move easily from a customary or inch project to a metric project, and back again. Individuals who were newly hired to work on a metric product line had easy access to metric training programs and, thus, did not appear to be limited by their lack of understanding of metric measurement when applying for a job or a promotion. Therefore, career issues do not appear to be significantly impacted by metric change in the cases that we studied.

### 2. Elderly Workers Experience Anxiety

Interviews with elderly workers revealed that they experience a higher level of anxiety about metric measurement prior to attending a training program than they do afterwards. They also admitted that once they began to use metric measurement on the job, this anxiety was dispelled, and they became equally comfortable with metric measurement and inch measurement units. In some instances, senior tool and die makers expressed genuine enthusiasm for the ease with which metric measurement allowed them to do certain calculations dealing with tool design and layout work.

## D. COMPANION ISSUES

The primary emphasis of this study was on tool and training issues; however, the team was also asked to address a variety of companion issues. Each of these companion issues was to be studied only to the extent necessary to obtain results that would allow the U.S. Metric Board to determine if a problem existed that was worthy of future research. Each of these companion issues is addressed in a separate section below.

## 1. Collective Bargaining Is Addressing Metric Topics

At the visit sites that were represented by organized labor, the subject of who pays for metric tools had usually been addressed during the negotiating process. Typically, this was not identified as being a major issue, although in some cases language written into the labor contract clearly indicated who would pay for the metric tools that were required by the individual worker. The topic of metric training, on the other hand, does not appear to have been addressed to any extent by the collective bargaining process. Accordingly, it does not appear that any metric issues have a substantial impact on the collective bargaining process, although the process does seem to have accommodated the issue of reimbursement for metric tools rather easily and simply. In one union where the issue of metric tools is not currently addressed in the union contract, labor representatives felt that at future dates this might become a topic for inclusion in the contract.

According to one industrial relations expert, as well as some union executives, there is reason to believe that metric change should be the subject of collective bargaining. Under the National Labor Relations Act, and other laws governing labor relations, certain topics are deemed mandatory subjects of bargaining; on request, unions and employers must bargain over these subjects. Any technological change, or any change in operations which significantly affects employees represented by a union, is a mandatory subject of bargaining. Thus, if metric change had a significant effect on employees, it would be a mandatory subject of bargaining, and employers would be required to bargain over such a change.

## 2. Some Potential Safety Problems Exist

During each of the field site visits, MRC study team members interviewed both workers and management regarding potential safety problems that might arise as a result of a metric conversion. In most cases, the initial reaction to this question was that no safety issues existed; and, in fact, no specific examples of increased safety hazards were identified. However, the potential for such hazards appears to exist in cases where work tasks require a knowledge of specific measurement units. For example, a worker may, through experience, be able to look at a large piece of machinery and roughly estimate its weight in tons or thousands of pounds. On the other hand, that same worker may not be able to make an accurate judgement in metric tons and safely lift the item using a piece of equipment that is labelled only in metric units. When presented with this type of example, some of the interviewees acknowledged that there may be occasions when increased safety hazards could result from a customary to metric measurement conversion.

## 3. Productivity May Be Impacted By Metric Change

The impact of metric change on the productivity of workers was also discussed during each site visit, and our findings on this issue varied

considerably between the production/manufacturing industries and the service industries we visited.

In the production and the manufacturing companies, both the workers and the management personnel who were interviewed indicated that during the initial use of metric measurement, there might have been some very small adjustments in productivity; however, these never lasted long enough to be noticeable or measured. The area in which change was most noticeable was quality control, where inspectors had to remember whether to use metric gauges or inch gauges on a particular product they were checking.

In contrast, the impact on productivity in the automotive, tractor, and truck maintenance industries appears to be somewhat more observable. The mechanics who were interviewed for this study indicated that when they have to perform maintenance on a vehicle that is a hybrid (that is, composed of both metric and inch fasteners), it is quite difficult to identify in advance where the metric fasteners are. Therefore, when they go in to remove a part or disassemble a vehicle, they are never sure which wrenches will be required. The mechanics contended that this causes a noticeable loss of productivity while they grab wrenches and attempt by trial and error to determine whether a particular bolt is in customary or metric units. Since mechanics are often paid on a piece rate basis, this trial and error process may have some impact on the amount of work they can perform in a given 8-hour day and, thus, the amount of money they earn. However, it should also be noted that the flat rates used for estimating, charging, and billing purposes in these industries normally take into account a number of factors, including a broad estimate of the time that will be required to perform a task (i.e., a brake overhaul or a transmission overhaul). Therefore, the decline in productivity would have to be substantial in order for it to have any detectible impact on the establishment of flat rates.

## E. ADDITIONAL ISSUES

During the course of this study, some of the people who were interviewed raised issues that were not initially considered part of the study. Since a number of these issues were raised on more than one occasion, it is appropriate to identify these items for the United States Metric Board so that they may decide whether to deal with them at a future date.

### 1. Confusion Exists Regarding the U.S. Metric Conversion Activities

A number of managers who were interviewed by MRC indicated that they and their organizations were confused by the United States' apparent lack of direction with respect to metric change. These individuals have been involved in both discussions and activities relating to metric change in the U.S. over the past five to ten years. The general thrust of their concern was that approximately five years ago, the United States appeared to be headed toward the use of metric measurement throughout industry.

However, at the present time, there seems to be much less enthusiasm for wholehearted use of metric measurement. Consequently, many organizations and industries that initiated metric planning programs and metric change activities subsequently slowed down or eliminated their efforts in this area. Further, these organizations perceive that they will be required to work in both inch and metric units for many more years than they had originally anticipated. They view this lengthened period of dual usage as being very costly, frustrating, and confusing when compared with other alternatives. The general attitude of these people was that, having started down the road to metric usage, we should continue with a reasonably paced, well thought-out program that will keep the costs of conversion to a minimum. These companies are wary of making independent commitments to a metric change program without the support of a nationwide program.

2. Dissemination of Education Materials is Nonexistent

Most of the industry personnel who were interviewed noted that when they were ready to introduce a metric training program it was difficult to locate existing training materials for metric subjects. Individual companies have had to identify what metric training materials are available through commercial suppliers or local technical institutes because there is no "information clearinghouse" on the subject. As a result, many organizations have duplicated the efforts of others in designing new metric materials or in modifying existing materials. The consensus of the people who were interviewed was that a logical function of the United States Metric Board would be to facilitate the dissemination of educational materials so that organizations desiring to conduct metric training could readily identify a starting point for this activity. This function is not provided by the Department of Education, ANMC, or the U.S. Metric Association.

3. Labor Involvement is Essential

One of the key elements that appears to have contributed to the success of metric change programs was early involvement of the employees in the process of change. This involvement took various forms, depending on the nature of the business and the size of the work force. In some cases, informal involvement of foremen and supervisors was all that was necessary. In other instances, labor representatives were involved in planning the changes early in the process. One of the advantages of labor's involvement was that it helped to remove the natural "fear of the unknown" associated with any impending change. This fear is compounded substantially if the change is basically a surprise to those involved. In one case, the employees were not involved in the process until after it had begun. Therefore, that particular initial program for metric change did not proceed as smoothly as it might.

# VI. RECOMMENDATIONS

This chapter of the report summarizes the specific recommendations that the United States Metric Board should consider as a result of this study. One general conclusion that can be drawn from the data presented in Chapter V of this report is that metric change is proceeding in a number of industries without major traumatic effects on the work force. However, there are some issues involving individual tool costs, safety, and training materials that should be considered.

## A. SAFETY ISSUES SHOULD BE STUDIED IN DETAIL

One of the companion issues that was addressed in this study was the extent to which metric change creates the risk of increased safety hazards in the work place. When the topic of safety issues was raised during the on-site interviews, most of the study participants stated that there were no safety hazards related to metric change. However, when the discussions continued as to whether specific incidents might occur in jobs involving the lifting of objects with cranes, inflation of tires, use of high pressure gases, or other similar work tasks, about half of the participants decided that some safety issues might exist. For example, a worker whose job involves lifting heavy equipment with an overhead crane may experience difficulty in safely estimating the weight of units if the units' markings have been changed from U.S. tons to metric tons. Since this study was not intended to focus on a detailed analysis of safety issues, MRC did not examine them in any depth. Our conclusion is, however, that sufficient potential for safety hazards appears to exist to justify a detailed study by the United States Metric Board. Our recommendation is that such a study should focus on identifying the possibility of increased safety hazards in specific job tasks that require the use of measurement units.

## B. ESTABLISH AN EDUCATIONAL CLEARINGHOUSE

All of the participants in our study indicated that their initial attempts to locate metric training materials were hampered by a lack of information regarding the sources of such materials. Over the last ten years, numerous organizations have spent a great deal of time and effort on developing metric training materials. These organizations include private industry, commercial training firms, technical colleges, high schools, unions, trade associations, and others. Their efforts have produced training materials in a variety of media, from printed booklets to films to videotapes. Unfortunately, there is no organization which functions as a clearinghouse to identify the sources of these training materials. One of the roles of the United States Metric Board could be to offer a metric training materials clearinghouse service. This service would provide a listing of available training materials to anyone interested in presenting

a metric training program. The value of this service in future years would be that it would reduce the continuous duplication of effort that appears to be going on in the development of metric training materials throughout the country. Our recommendation is that the USMB establish a metric training materials clearinghouse service.

## C. CONSIDER TAX CREDITS

Based on the results of this study, it appears that the cost of individual tools is in many cases borne by the employer. However, there is also a large group of individuals, primarily workers in small organizations and the service and construction industries, who have to bear the cost of their own metric tools. For most of these individuals, the cost will be well under $200. However, in some of the service industries, such as automotive or truck maintenance, these costs could run as high as $500 to $1000 per person.

Under current income tax regulations, individuals who itemize deductions can claim the cost of expenses that are required in the conduct of their work and are not reimbursed by their employer. This would cover metric tools if the purchase of these tools was a condition of employment. However, this provision of the tax laws requires the taxpayer to complete the "long form" and to itemize deductions on a separate schedule. Accordingly, many workers who might be eligible to deduct the cost of metric tools are either unaware of their eligibility or sufficiently discouraged by the forms so that they do not avail themselves of this deduction. Further, this is simply a deduction, not a tax credit; therefore, the average worker would only recover about 20% to 30% of the cost of the tools. Our recommendation is that the United States Metric Board, in conjunction with the Treasury Department, should explore the value of providing direct tax credits to individuals up to a specified limit that could be deducted directly from taxes due. These tax credits would probably be most effective if they were implemented in a fashion similar to child care credits.

## SUMMARY LISTING OF OCCUPATIONAL CATEGORIES, DIVISIONS, AND GROUPS

### Occupational Categories

0/1 Professional, technical, and managerial occupations
2 Clerical and sales occupations
3 Service occupations
4 Agricultural, fishery, forestry, and related occupations
5 Processing occupations
6 Machine trades occupations
7 Benchwork occupations
8 Structural work occupations
9 Miscellaneous occupations

## TWO-DIGIT OCCUPATIONAL DIVISIONS

### Professional, Technical, and Managerial Occupations

00/01 Occupations in architecture, engineering, and surveying
02 Occupations in mathematics and physical science
04 Occupations in life sciences
05 Occupations in social sciences
07 Occupations in medicine and health
09 Occupations in education
10 Occupations in museum, library, and archival sciences
11 Occupations in law and jurisprudence
12 Occupations in religion and theology
13 Occupations in writing
14 Occupations in art
15 Occupations in entertainment and recreation
16 Occupations in administrative specializations
18 Managers and officials, n.e.c.
19 Miscellaneous professional, technical, and managerial occupations

### Clerical and Sales Occupations

20 Stenography, typing, filing, and related occupations
21 Computing and account-recording occupations
22 Production and stock clerks and related occupations
23 Information and message distribution occupations
24 Miscellaneous clerical occupations
25 Sales occupations, service
26 Sales occupations, consumable commodities
27 Sales occupations, commodities, n.e.c.
29 Miscellaneous sales occupations

## Service Occupations

30 Domestic service occupations
31 Food and beverage preparation and service occupations
32 Lodging and related service occupations
33 Barbering, cosmetology, and related service occupations
34 Amusement and recreation service occupations
35 Miscellaneous personal service occupations
36 Apparel and furnishings service occupations
37 Protective service occupations
38 Building and related service occupations

## Agricultural, Fishery, Forestry, and Related Occupations

40 Plant farming occupations
41 Animal farming occupations
42 Miscellaneous agricultural and related occupations
44 Fishery and related occupations
45 Forestry occupations
46 Hunting, trapping, and related occupations

## Processing Occupations

50 Occupations in processing of metal
51 Ore refining and foundry occupations
52 Occupations in processing of food, tobacco, and related products
53 Occupations in processing of paper and related materials
54 Occupations in processing of petroleum, coal, natural and manufactured gas, and related products
55 Occupations in processing of chemicals, plastics, synthetics, rubber, paint, and related products
56 Occupations in processing of wood and wood products
57 Occupations in processing of stone, clay, glass, and related products
58 Occupations in processing of leather, textiles, and related products
59 Processing occupations, n.e.c.

## Machine Trades Occupations

60 Metal machining occupations
61 Metalworking occupations, n.e.c.
62/63 Mechanics and machinery repairers
64 Paperworking occupations
65 Printing occupations
66 Wood machining occupations
67 Occupations in machining stone, clay, glass, and related materials
68 Textile occupations
69 Machine trades occupations, n.e.c.

## Benchwork Occupations

70 Occupations in fabrication, assembly, and repair of metal products, n.e.c.
71 Occupations in fabrication and repair of scientific, medical, photographic, optical, horological, and related products
72 Occupations in assembly and repair of electrical equipment
73 Occuptions in fabrication and repair of products made from assorted materials
74 Painting, decorating, and related occupations
75 Occupations in fabrication and repair of plastics, synthetics, rubber, and related products
76 Occupations in fabrication and repair of wood products
77 Occupations in fabrication and repair of sand, stone, clay, and glass products
78 Occupations in fabrication and repair of textile, leather, and related products
79 Benchwork occupations, n.e.c.

## Structural Work Occupations

80 Occupations in metal fabricating, n.e.c.
81 Welders, cutters, and related occupations
82 Electrical assembly, installing, and repairing occupations
84 Painting, plastering, waterproofing, cementing, and related occupations
85 Excavating, grading, paving, and related occupations
86 Construction occupations, n.e.c.
89 Structural work occupations, n.e.c.

## Miscellaneous Occupations

90 Motor freight occupations
91 Transportation occupations, n.e.c.
92 Packaging and materials handling occupations
93 Occupations in extraction of minerals
95 Occupations in production and distribution of utilities
96 Amusement, recreation, motion picture, radio and television occupations, n.e.c.
97 Occupations in graphic art work

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APPENDIX II

LIST OF DOT CLASSIFICATIONS WITHIN OCCUPATIONS TO BE STUDIED

502 Melting, Pouring, Casting, and Related Occupations

Supervisor, Casting-and-Pasting (elec. equip.)
Shot Dropper (ammunition)
Caster (jewelry) molder; slush caster
Molder, Punch (aircraft-aerospace mig.) molder; molder, closed molds
Bullet-Slug-Casting-Machine Operator (ammunition) machine-casting operator and adjuster
Fluoroscope Operator (aircraft-aerospace mig.; nonfer, metal alloys)
Caster (nonfer, metal alloys)
Casting-Machine Operator, Automatic (elec. equip.) parts-casting-machine operator
Rotor Castinq-Machine Operator (elec. equip.) die-casting machine operator
Blast-Furnace Keeper (iron & steel)
Steel Pourer (iron & steel) caster
Steel-Pourer Helper (iron & steel)
Bullet-Casting Operator (ammunition)
Casting-Machine Operator (nonfer, metal alloys)
Centrifugal-Casting-Machine Operator (jewelry) caster
Lead Caster (elec. equip.) Parts caster, hand
Mill Helper (nonfer, metal alloys) lead-sheet cutter
Mold Setter (elec. equip.) casting-machine adjuster
Needle Leader (needle, pin & rel. prod.) needle
Molder, Lead Ingot (ammunition)
Remelter (elec. equip.; print. & pub.; type founding)
Casting-Machine-Operator Helper (elec. equip.) grid-casting-machine-operator helper
Blast-Furnace Keeper Helper (iron & steel)
Busher (abrasive & polish. prod.)
Lead Caster (elec. equip.)

600 Machinists and Related Occupations

Machine-Shop Supervisor, Tool (mach. shop)
Salvage Engineer (mach. mfg.)
Engineering Model Maker (inst. & app.)
Experimental Mechanic (motor. & bicycles) development mechanic
Model Maker, Firearms (firearms) sample maker
Assembler, Steam-and-Gas Turbine (engine & turbine) leadman, turbine assembly.
Instrument Maker (any ind.) mechanical technician; parts mechanic; precision-instrument and tool maker; precision-mechanical-instrument maker
Instrument Maker and Repairer (petrol. production)
Instrument Maker Apprentice (any ind.) precision-mechanical-instrument-maker apprentice
Machinist (mach. shop) machinist, all-around; machinist, first class; machinist, general; machinist, precision
Machinist Apprentice (mach. shop) machine- shop apprentice
Machinist Apprentice, Automotive (auto. ser.)
Machinist, Automotive (auto. ser.)

## Benchwork Occupations

70 Occupations in fabrication, assembly, and repair of metal products, n.e.c.
71 Occupations in fabrication and repair of scientific, medical, photographic, optical, horological, and related products
72 Occupations in assembly and repair of electrical equipment
73 Occuptions in fabrication and repair of products made from assorted materials
74 Painting, decorating, and related occupations
75 Occupations in fabrication and repair of plastics, synthetics, rubber, and related products
76 Occupations in fabrication and repair of wood products
77 Occupations in fabrication and repair of sand, stone, clay, and glass products
78 Occupations in fabrication and repair of textile, leather, and related products
79 Benchwork occupations, n.e.c.

## Structural Work Occupations

80 Occupations in metal fabricating, n.e.c.
81 Welders, cutters, and related occupations
82 Electrical assembly, installing, and repairing occupations
84 Painting, plastering, waterproofing, cementing, and related occupations
85 Excavating, grading, paving, and related occupations
86 Construction occupations, n.e.c.
89 Structural work occupations, n.e.c.

## Miscellaneous Occupations

90 Motor freight occupations
91 Transportation occupations, n.e.c.
92 Packaging and materials handling occupations
93 Occupations in extraction of minerals
95 Occupations in production and distribution of utilities
96 Amusement, recreation, motion picture, radio and television occupations, n.e.c.
97 Occupations in graphic art work

Machinist, Experimental (mach. shop)
Maintenance Machinist (any ind.) machine repairer; shop mechanic; machinist
Patternmaker Apprentice, Metal (found.)
Patternmaker, Metal (found.)
Sample Maker, Appliances (elec. equip.) model maker
Fluid-Power Mechanic (any ind.)
Lay-out Inspector (forgoing; found.; mach. shop) inspector, rough castings; lay-out worker
Lay-out Worker (mach. shop)
Machine Builder ( mach. mfg,; mach. tool & access.) assembler, special machine; bench hand; fitter; machinist, bench; vise hand
Machine Try-out Setter (mach. tool & access.) detail maker and fitter
Fixture Maker (light. fix.)
Job Setter (fabric, plastics prod.; mach. mfg.; mach. shop) machine adjuster; machine setter; machinist, tool setter
Machine Set-Up Operator (elec. equip.; firearms; mach. shop) machine operator, all around; machine operator, general; machinist
Machine Setter (clock & watch)
Turbine-Blade Assembler (engine & turbine)
Propeller Lay-out Worker (aircraft-aerospace mfg.)

601 Toolmakers and Related Occupations

Tool-and-Die Supervisor (mach. shop)
Die Maker, Stamping (mach. shop) body-die maker
Die Maker, Trim (mach. shop) trim die maker; trimmer maker
Die Maker, Wire Drawing (mach. shop)
Die Sinker (mach. shop) forgoing die sinker
Mold Maker, Die-Casting and Plastic Molding (mach. shop) die-cast-die maker; mold maker, plastic molds
Tap-and Die-Maker Technician (clock & watch)
Template Maker, Extrusion Die (mach. shop)
Tool Maker (mach. shop)
Tool and Die Maker (mach. shop)
Tool and Die Maker Apprentice (mach. shop)
Tool Machine Set Up Operator (mach. shop) machine-tool operator, general; machinist; set up operator, tool
Tool Maker Apprentice (mach. shop)
Die Maker, Bench, Stamping (mach. shop) bench die maker; die maker; Stamping-die maker, bench
Die-Try-Out Worker, Stamping (mach. shop)
Inspector, Gage and Instrument (mach. shop) Gage checker
Inspector Tool (mach. shop) precision inspector; surface-plate inspector; tool-and-die inspector; tool-and-gage inspector
Tool Maker, Bench (mach. shop)
Carbide Operator (mach. shop) carbide grinder
Die Finisher (mach. shop) die fitter
Die Maker (jewelry) die cutter; hub cutter
Die Polisher (wire)
Die Maker Apprentice (jewelry) die-cutter apprentice; hub-cutter apprentice
Plastic Tool Maker (mach. shop)

Plastic Fixture Builder (mach. shop) model maker, plastic
Saw Maker (cut. & tools) saw mechanic
Template Maker (any ind.)
Profile-Grinder Technician (clock & watch)
Tool Dresser (any ind.) drill-sharpener operator

616 Fabricating Machine Occupations

Supervisor (nut & bolt)
Supervisor, Specialty Manufacturing (iron & steel)
Supervisor, Spring Production (spring)
Supervisor, Steel Division (matt. & bedspring)
Embossing Toolsetter (ammunition)
Multi-Operation-forming-machine setter (any ind.)
Spring Coiling Machine Setter (spring)
Torsion Spring Coiling Machine Setter (spring)
Spring Maker (spring)
Body-Maker-Machine setter (tinware)
Loom Setter, Wire Weaver (wirework)
Machine Operator (any ind.) I fabricating machine operator
Machine Setter (any ind.)
Multi-operation-forming-machine operator (any ind.) I
Shotgun-shell-assembly-machine adjuster (ammunition) assembly-machine
tool setter; heading-and-priming tool setter
Straight-line-press setter (ammunition) assembly-machine tool setter;
tracer-bullet assembly-machine tool setter
Spring Inspector (spring) I
Fabric Machine Operator (matt. & bedspring) I link-wire-fabric-machine
operator
Four slide machine setter (any ind.)
Job setter (electronics)
Barbed wire machine operator (wirework)
Wire Weaver, cloth (wirework) wire weaver
Nail making machine setter (nail) nail machine operator
Safety pin assembling machine operator (needle, pin & rel. prod.)
Truer (spring)
Bench worker (spring)
Spring Coiler (spring) coil machine operator
Fence making machine operator (wirework)
Hydraulic press operator (const.)
Tensioning machine operator (conc. prod.)
Weaver, bench loom (wirework)
Arbor press operator (any ind.) I floor press operator
Bale tie machine operator (wirework) wire looping machine operator
Cage maker, machine (conc. prod.)
Crimping machine operator (any ind.)
Kick press operator (any ind.) I assembler, press operator; bench press
operator
Nail assembly machine operator (nail)
Stranding machine operator (elec. equip.; insulated wire; wirework;)
cable machine operator; strander operator; strand machine operator
Chain testing machine operator (forgoing)
Clinching machine operator (elec. equip.)
Coil assembler machine (matt. & bedspring) automatic coil machine
operator; coil tier; finisher

Fabric machine operator (matt. & bedspring) II link fabric machine
operator; link wire fabric machine tender
Heedle machine operator (mach. mfg.)
Knitter, wire mesh (wirework) knitting machine operator
Load tester (spring)
Metal sponge making machine operator (nonfer, metal alloys)
Multi operation forming machine operator (any ind.) II forming mill
operator; roll-mill operator
Paperback machine operator (wirework) weaving machine operator
Pocket machine operator (matt. & bedspring) pocketed spring machine operator
Riveter (light fix.)
Riveting machine operator (furn.) machine reveter; rivet hammer
machine operator
Scroll machine operator (struct. & ornam. metalwork)
Slat twister (matt. & bedspring)
Spiral spring winder (spring) recoil spring winder
Spiral Weaver (wirework)
Swager operator (pen & pencil)
Sweep press Operator (clock & watch)
Wire coiner (needle, pin & rel prod.)
Zipper cutter (needle, pin & rel prod.)
Stranding machine operator helper (wirework) cable mill helper
Wire weaver helper (wirework) loom helper

620 Motorized vehicle and engineering equipment mechanics and repairers

Supervisor, endless track vehicle (auto. ser.)
Supervisor, Garage (auto ser.) automobile mechanic supervisor; mechanic
chief; transportation department supervisor
Supervisor, Motorcycle repair shop ( auto ser.)
Tank and Amphibian Tractor Operations chief (military ser.)
Automobile Mechanic (auto. ser.) garage mechanic
Automobile mechanic apprentice (auto ser.) automobile and truck mechanic
apprentice
Automobile tester (auto. ser.)
Automobile repair service estimator (auto ser.) automobile inspector;
collision estimator; manager, service; mechanic, trouble shooting;
sales associate, garage service; service writer
Construction equipment mechanic (const.) heavy equipment mechanic
Electric golf cart repairer (amuse. & rec.; auto. ser.) golf cart mechanic
Air conditioning mechanic (auto ser.) automobile refrigeration mechanic
Automotive technician, exhaust emissions (gov. ser.) power equipment mechanic
Automotive maintenance equipment servicer (any. ind.) automotive maintenance
equipment repairer; equipment service engineer; pump and tank servicer
Braker Repairer (auto. ser.) brake mechanic; brake repair mechanic;
brakeshoe repairer
Bus Inspector (auto. ser.) motor inspection mechanic
Carburetor mechanic (auto ser.) carburetor repairer
Front end mechanic (auto ser.) alinement mechanic; axle and frame mechanic;
chassis mechanic; wheel alinement mechanic
Logging equipment mechanic (logging)
Maintenance mechanic (const.; petrol. production; pipelines) service
engineer; shop mechanic

Mechanical, industrial truck (any ind.) truck repairer
Motorcycle repairer (auto. ser.) motorcycle mechanic
Tractor mechanic (auto. ser.)
Transmission mechanic (auto. ser.)
Tune-up mechanic (auto. ser.)
Vehicle fuel systems converter (auto. ser.)
Squeak, rattle, and leak repairer (auto. ser.)
Automobile radiator mechanic (auto. ser.) automobile mechanic, radiator; radiator repairer
Mechanic, endless track vehicle (auto. ser.)
Mechanical unit repairer (auto. ser.; loco. car bldg & rep.)
Repairer, Heavy (auto mfg.)
Motorcycle tester (motor. & bicycles)
Spring repairer helper, hand (auto. ser.) spring fitter helper; spring maker hand; tear up worker, spring
Construction equipment mechanic helper (const.)
Maintenance mechanic helper (const.; petrol. production; pipe lines) mechanic helper; shop mechanic helper
Brake drum lathe operator (auto ser.) machinist, brake
Automobile wrecker (whole tr.) wrecking mechanic
Automobile mechanic helper (auto ser.)
Brake adjuster (auto. ser.)
Clutch rebuilder (auto ser.)
Motorcycle subassembly repairer (motor. & bicycles)
Tractor mechanic helper (auto ser.)
Used car renovator (ret. tr.) used car conditioner
Bonder, automobile brakes (auto. ser.)

621 Aircraft mechanics and repairers

Supercharge repair supervisor (air trans.)
Supervisor, aircraft maintenance (aircraft aerospace mfg.; air trans.)
Supervisor, production department (aircraft aerospace mfg.)
Supervisor, reclamation (whole tr.)
Airplane inspector (air trans.) airplane and engine inspector
Engine tester (aircraft aerospace mfg.; air trans.)
Flight engineer (air trans.) flight mechanic
Air conditioning check out mechanic (air craft aerospace mfg.)
Airframe and power plant mechanic
Airframe and power plant mechanic apprentice (aircraft aerospace mfg.; air trans.) airplane mechanic apprentice
Experimental mechanic (aircraft aerospace mfg.) II experimental aircraft and engine mechanic, field and hangar; mechanic, engineering research
Mechanic, field and service (aircraft aerospace mfg.) engine-service mechanic
Rocket engine component mechanic (aircraft aerospace mfg.)
Flight test shop mechanic (aircraft aerospace mfg.) experimental aircraft and engine electrician, field and hangar; test structures mechanic
Mechanic, aircraft accessories (aircraft aerospace mfg.) mechanic, accessory rework and repair
Mechanic, flowmeter test and certification (aircraft aerospace mfg.)

Pneumatic tester and mechanic (aircraft aerospace mfg.)
Airframe and power plant mechanic helper (aircraft aerospace mfg.; air trans.) airplane mechanic helper
Reclamation worker (whole tr.)

622 Rail Equipment Mechanics and Repairers

Supervisor, railroad car repair (loco. & car bldg & rep.)
Supervisor, roundhouse (loco. & car bldg & rep.)
Supervisor, wheel shop (loco. & car bldg & rep.)
Locomotive inspector " " " pit inspector
Air valve repairer " " "
Car repairer " " " drop pit worker; machinist
Car repairer, pullman (r.r. trans.)
Car repairer apprentice (loco. & car bldg & rep.) machinist apprentice
Floor covering layer " " "
Mine car repairer (mining & quarrying) pit car repairer; shop blacksmith
Railroad wheels and axel inspector (loco. & car bldg & rep.) wheel and axel inspector
Salvage inspector (loco. & car bldg & rep.)
Triple air valve tester (loco. & car bldg & rep.) test rack operator
Air compressor mechanic " " " compressor repairer
Car repairer helper " " " machinist helper
Switch repairer (R.R. trans.)

625 Engine, Power Transmission, and Related Mechanics

Engine testing supervisor (engine & turbine)
Supervisor, engine repair " "
Diesel engine tester " "
Diesel mechanic (any ind.)
Diesel mechanic " " diesel engine mechanic apprentice
Engine repairer, service (engine & turbine)
Fuel injection servicer (any ind.)
Gas engine repairer " "
Power saw mechanic " " chain saw mechanic
Small engine mechanic " "
Diesel engine erector (engine & turbine) diesel engine fitter
Engine Repairer, production (engine & turbine)
Diesel mechanic helper (any ind.)

633 Business and Commercial Machine Repairers

Office Machine Service Supervisor (any ind.)
Assembly technician (office mach.)
Mail Processing equipment mechanic (gov. ser.)
Cash register servicer (any ind.) cash register repairer
Dictating transcribing machine servicer (any ind.)
Office Machine Servicer (any ind.) business machine mechanic; office equipment mechanic; office machine inspector
Office machine servicer apprentice (any ind.) business machine mechanic apprentice
Scale mechanic (any ind.)
Statistical machine servicer (any ind.) customer engineer

771 Stone Cutters and Carvers

Supervisor, slate splitting (stonework)
Stencil cutter (stonework) blaster; rubber cutter shape carver
Stone Carver " hand carver; sculptor
Stonecutter apprentice, hand (stonework) granite cutter apprentice
Stonecutter, hand (stonework) chisel worker; stone dresser; stoneworker
Coper, hand " Cutter; marble coper
Beveler "
Rock splitter " block maker; driller

810 ARC Welders and Cutters

Welding machine operator, ARC (welding)
Welder apprentice, ARC "
Welder, ARC "
Welder, gun "
Welder, tack " tacker

820 Occupations in Assembly, Installation, and Repair of Generators, Motors, Accessories, and Related Powerplant Equipment

Electrician Supervisor, Substation (light, heat, & power) electric repair supervisor; special inspecting and testing supervisor
Transformer Assembly Supervisor (elec. equip.)
Electrician apprentice, powerhouse (light, heat & power)
Electrician, powerhouse " " "
Electrician, Substation " " "
Corrosion control fitter ( " " " ; pipe lines)
Electric motor generator assembler (elec. equip.) assembler erector; motor and generator assembler
Regulator Inspector (light, heat & power)
Battery maintainer, large emergency storage (light, heat & power)
Transformer assembler (elec. equip.)
Motor room controller (light, heat & power)

821 Occupations in Assembly, Installation, and Repair of Transmission and Distribution Lines and Circuits

Electrician installation supervisor (light, heat & power) service inspector
Line supervisor " " "
Service supervis " " "
Steel post installer supervisor " " "
Wireworker supervisor " " " electrician-constructor supervisor
Community antenna television line technician (bus. ser.; ret. tr.)
Line maintainer (any ind.)
Relay technician (light, heat & power)
Service restorer, emergency (r.r. trans.)
Trouble shooter (light, heat & power)
Television cable installer (any ind.)
Cable installer repairer (light, heat & power) electrician, underground
Electric meter installer " " " I
Line erector (const.; " " "

Line Installer, street railway (r.r. trans.) line installer, trolley
Line repairer (light, heat & power) hiker; line servicer
Line erector apprentice (const.; light, heat & power)
Power transformer repairer ( " " " transformer assembler
Tower erector (const.; light, heat & power)
Utilities service investigator (light, heat & power) electric meter inspector
Construction checker " " " inspector and clerk; power line inspector
Safety inspector (light, heat & power)
Electric meter tester (light, heat & power) meter tester
Voltage tester " " " service tester
Laboratory helper " " "
Helper, electrical " " " elctrician helper
Electric meter installer (light, heat & power) II
Tower erector helper (const.; light, heat & power)
Wirer, street light ( " " "
Steel post installer " " " laborer, pole crew; pole setter

822 Occupations in Assembly, Installation, and Repair of Wire Communication, Detection and Signaling Equipment

Central office repairer supervisor (tel. & tel.) installation supervisor; maintenance chief; operations chief; wire chief
Customer Facilities supervisor (tel & tel) maintenance supervisor; manager, service; service center supervisor
Line supervisor (tel & tel)
Protective signal superintendent (bus. ser.) burglar alarm superintendent
Signal supervisor (r. t. trans.)
Test desk supervisor (tel & tel)
Electrician, office " " electrician, station, assistant
Equipment inspector " "
Maintenance inspector " "
Station installer and repairer (tel & tel)
Testing and Regulating technician (tel & tel) automatic maintainer; repeater attendant; technician, terminal and repeater; wire and repeater technician; tester, equipment
Line inspector (tel & tel) inspector, line
Automotive equipment technician (tel & tel) technician, automatic; telgraph equipment maintainer
Central office repairer (tel & tel) central office maintainer
Maintenance mechanic, telephone (any ind.) electrician telephone
Private branch exchange repairer (tel & tel) pbx repairer; telephone repairer
Signal Maintainer (r.r. trans.) signal inspector; signal repairer
Technician, plant and maintenance (radio & tv broad)
Technician, submarine cable equipment (tel & tel)
Cable tester " "
Central office installer " " equipment installer
Protective signal installer (bus. ser.) burglar alarm installer; installer
Protective signal repairer " " " " " and servicer
Transmission Tester (tel & tel)
Trouble locator, test desk (tel & tel) dispatcher
Equipment installer " "
Line Installer repairer " "
Private branch exchange installer (tel & tel) pbx installer

Telegraph plant maintainer (tel & tel) equipment installer; maintainer, central office; maintainer, equipment; maintainer, plant
Protective signal installer helper (bus. ser.)
Frame wirer (tel & tel)
Protective signal repairer helper (bus. ser.) burglar alarm repairer helper
Signal maintainer helper (r.r. trans.) assistant signal maintainer

827 Occupations in Assembly, Installation, and Repair of Large Household Appliances and Similar Commercial and Industrial Equipment

Electrical appliance servicer supervisor (any ind.)
Supervisor, major appliance assembly (elec. equip.)
Electrical appliance servicer (any ind.) appliance service representative
Electrical appliance servicer apprentice (any ind.) major appliance servicer apprentice, electrical
Air conditioning unit tester (refrigerator equip.)
Refrigeration mechanic " "
Control panel tester (elec. equip.)
Wind tunnel mechanic (aircraft aerospace mfg.)
Refrigerator tester (refrigerator equip.)
Air conditioning installer, domestic (any ind.) air conditioning-window box installer
Gas charger (refrigerator equip.) charging board operator
Electrical appliance preparer (any ind.) uncrater
Gas leak tester (refrigerator equip.)
Foam charger " "
Household appliance installer (any ind.)
Appliance assembler, line (elec. equip.; refrigerator equip.)

860 Carpenters and Related Occupations

Supervisor, acoustical tile carpenters (const.)
Supervisor, boatbuilders, wood (ship & boat bldg & rep.) carpenter supervisor, wooden ship
Supervisor, carpenters (const.)
Supervisor, joiners (ship & boat bldg & rep.)
Supervisor, mold construction (conc. prod.)
Carpenter labor supervisor (const.)
Carpenter inspector (any ind.)
Carpenter, maintenance (any ind.) carpenter, repair; carpentry repairer
Carpenter, ship (water trans.)
Acoustical carpenter (const.) acoustical material worker; metal tile lather
Boatbuilder apprentice, wood (ship & boat bldg. & rep.)
Boatbuilder, wood " " "
Carpenter (const.)
Carpenter apprentice (const.)
Carpenter, bridge (r.r. trans.) bridge repairer
Carpenter, mold (brick & tile; conc. prod.) moldforms builder; patternmaker
Carpenter, railcar (loco. & car bldg & rep.)
Carpenter, rough (const.) bracer
Form builder " carpenter, form; wood form builder
Joiner (ship & boat bldg & rep.) boat joiner

Joiner apprentice (ship & boat bldg & rep.)
Shipwright " " " carpenter, ship; woodworker
Shipwright apprentice (ship & boat bldg & rep.) carpenter apprentice, ship
Tank builder and erector (const.) tank maker, wood
Carpenter (mfd. bldgs.) I
Joiner helper (ship & boat bldg & rep.)
Shipwright helper (ship & boat bldg & rep.) carpenter helper; woodworker helper
Carpenter (mfd. bldgs.) II
Builder, beam (mfd. bldgs.)
Sider " "

861 Brick and Stone Masons and Tile Setter

Bricklayer supervisor (const.)
Chimney supervisor, brick (const.)
Stonemason supervisor "
Supervisor, marble "
Supervisor, terrazzo "
Stonemason apprentice " stone rigger; stone setter apprentice
Terrazzo worker " artificial marble worker; floor grinder
Terrazzo worker apprentice "
Tile setter " tile fitter; tile layer; tile mason
Tile setter apprentice "
Tile conduit layer "
Cupola patcher (found.) cupola liner
Patcher (coke prod.)
Tile setter (mfd. bldgs.)
Bricklayer helper, firebrick, and refractory tile (const.) brickmason helper
Patcher helper (coke prod.) helper, patcher

862 Plumbers, Gas Fitters, Steam Fitters, and Related Occupations

Pipe fitter supervisor (const.)
Pipe fitter supervisor (ship & boat bldg & rep.)
Plumber supervisor (const.)
Supervisor, pipelines (petrol. production) gang supervisor, pipe lines; roustabout, head
Well point pumping supervisor (const.)
Suction dredge pipe line placing supervisor (const.) shore working supervisor; suction dredge dumping supervisor
Supervisor, water softener service (bus. ser.)
Mains and Service supervisor (light, heat & power) gas distribution supervisor
Steam distribution supervisor " " " chief maintenance supervisor
Pipe fitter (ship & boat bldg & rep.) pipe fitter, marine
Coppersmith " " "
Coppersmith apprentice (ship & boat bldg & rep.)
Oil burner servicer and installer (any ind.)
Furnance installer (light, heat & power)
Gas main fitter " " "
Pipe fitter, diesel engine (engine & turbine) I piper
Steam service inspector (light, heat & power) inspector, outside steam distribution; manhole and underground steam line inspector

Aircraft mechanic, plumbing and hydraulics (aircraft aerospace mfg.) aircraft plumbing and hydraulics assembler; research test mechanic hydraulic; tubing installation assembler
Industrial gas fitter (light, heat & power) industrial servicer
Pipe fitter (const.) plumber, pipe fitting
Pipe fitter, diesel engine (engine & turbine) II
Pipe fitter apprentice (const.) air conditioning mechanic apprentice; refrigeration mechanic apprentice; steam fitter apprentice
Plumber (const.)
Plumber apprentice (const.)
Thread inspector (petrol. production) pipe thread inspector
Pipe cleaning and priming machine operator (const.)
Plumber (mfd. bldgs.)
Pipe cutter (mfd. bldgs.)
Pipe wrapping machine operator (const.; pipe lines)
Junction maker (brick & tile) branch maker; fitting maker
Laborer, construction or leak gang (light, heat & power)
Pipe fitter helper (ship & boat bldg & rep.)
Pipe fitter helper (const.) fitter helper
Plumbing assembler installer (mfd. bldgs.)
Water regulator and valve repairer (waterworks)
Water softener servicer and installer (bus. ser.)
Cooling pipe inspector (const.) pipe inspector
Holiday detector operator (const.) electric detector operator; jeeper operator; pipe jeeper
Hydro pneumatic tester (any ind.)

899 Miscellaneous Structural Work Occupations, N.E.C.

Supervisor, canal equipment maintenance (waterworks) maintenance supervisor
Labor crew supervisor (const.; light, heat & power)
Lock Maintenance Supervisor (const.)
Utilities and Maintenance supervisor (any ind.) maintenance and utilities supervisor
Utility supervisor, boat and plant (ship & boat bldg & rep.)
Supervisor, labor gang (any ind.) boss; bull gang supervisor; field supervisor; floating labor gang supervisor; general labor supervisor; group supervisor, yard; yard labor supervisor
Highway maintenance supervisor (gov. ser.)
Airport maintenance chief (air trans.) superintendent, maintenance, airports
Superintendent, track (const.)
Supervisor, maintenance (petrol. refin.) gang boss; gang pusher
Diver (any ind.) submarine worker
Canal equipment mechanic (waterworks)
Maintenance repairer, factory or mill (any ind.) plant maintenance worker; utility repairer, factory or mill
Chimney repairer (bus. ser.)
Maintenance repairer, building (any ind.) building repairer
Mobile home lot utility worker (ret. tr.) maintenance worker; house trailer
Tester (rubber goods)
Diver helper (any ind.) diver assistant; diver tender; life line attendant
Sewer pipe cleaner (bus. ser.) electric sewer cleaning machine operator
Diver pumper (const.; fish)
Bondactor machine operator (found.)

Highway maintenance worker (gov. ser.) highway worker
Laminator (rubber goods)
Maintenance repairer helper, factory or mill (any ind.) general
maintenance helper
Pipeliner (pipe lines)
Portable sawyer (loco. & car bldg & rep.)
Shaft mechanic (mining & quarrying) shaft repairer; shaft tender
Stripper and taper (rubber goods)
Window repairer (any ind.)
Decorator, street and buidling (any ind.)
Laborer, airport maintenance (air trans.)

953 Occupations in Production and Distribution of Gas

Supervisor, liquefaction and regasification (light, heat & power)
Gas pumping station supervisor " " "
Pressure supervisor " " "
pressure control supervisor; regulation supervisor
Service supervisor (light, heat & power) I complaint supervisor;
superintendent, service
Gas Dispatcher (light, heat & power; pipe lines)
Field mechanical meter tester (light, heat & power; petrol. refin.;
pipe lines) mechanical meter tester; meter inspector
Fuel attendant (any ind.)
Liquefaction and regasification plant operator (light, heat & power)
Pressure controller (light, heat & power)
Gas meter installer " " " gas fitter; meter installer
Gas leak inspector " " " ; pipe lines) leak locator;
maintenance inspector
Gas meter checker (light, heat & power) meter and service line inspector
House piping inspector (light, heat & power)
Gas pumping station operator (light, heat & power) compressor house
operator; engineer, booster and exhauster; engineer, gas pumping
station; gas substation operator
Cylinder inspector and tester (comp. & liquefied gases) cylinder tester;
gas cylinder inspector; hydrostatic tester
Drip pumper (light, heat & power; pipe lines)
Helper, liquefaction and regasification (light, heat & power)
Gas leak inspector helper " " " ; pipe lines)
Gas pumping station helper " " "
Gas meter installer helper " " "

PRIMARY CONTACTS FOR STUDY DATA

| | |
|---|---|
| Phillip Athen | Aluminum Company of America |
| Dick Latshaw | U.S. Steel |
| Wiley Rucker | Boland Marine |
| James Whately | Dixie Marine |
| Dan Keating | Louisiana Off-Shore Oil Port |
| Joseph Pregeant | Gulf Best Electric |
| Ed Wallock | Signode Corporation |
| Frank Churchill | Allis Chalmers |
| Louis Strang | Caterpillar Tractor Company |
| Ray Fairbank | John Deere |
| Jim Meronek | J.I. Case - Drott |
| Marvin Dubbs | Sun Petroleum Products |
| Bob Simmons | Gardiner Equipment |
| Fred Lee | Metric Service Center |
| John Spears | AFL-CIO Appalachian Council |
| Rolf Sheu | Bosch Injection |
| Kurt Egerter | Mayer, Rothkopf Industries |
| Ron Schubert | North Central Technical Institute |
| Marilyn Lillie | Regal-Beloit |
| Harold Stephen | Local 248 U.A.W. Milwaukee |
| John Thieler | Avondale Shipyard |
| M.T. McBride | Brown & Root |
| E. Chesson, Jr. | University of Delaware |
| Robert Wilson | Motor Vehicle Manufacturers Assoc. |
| Meredith Smith | FMC Corporation |
| E.D. Vosburgh | Chrysler Corporation |
| Samuel Balkan | Polaroid Corporation |
| John McDonald | IAM Lodge 698 Detroit |

## VISIT SUMMARIES

After each of the site visits, a concise summary was developed documenting the results of the visit. As part of this study of the blue collar worker involved in metric measurement, the issues of safety, collective bargaining, job mobility (or enhancement), and elderly workers were examined. Literature searches, as well as interviews with the workers, their managers, and trainers were done to obtain a well-focused picture of the worker for each issue. Each of these summaries was reviewed by the participants to verify the statements made regarding their approach to metric change. In two cases, individual site visits were combined into one participant summary due to the geographic locations and similarity of the work involved. Thus, three site visits in New Orleans at Boland Marine, Dixie Marine, and Gulf Best Electric were combined because of the similarities in their approach, size, and focus on marine maintenance. A second group of visits to individual Automotive Service Centers at Ford, Chevrolet, and Chrysler dealerships were combined into one participant summary addressing automotive service centers. Each of these visits is presented in the following pages as an independent summary report. A list of individuals contacted at each participating site may be found in Appendix III.

## AFL-CIO APPALACHIAN COUNCIL

Metric Education Project

The Appalachian Council Metric Education Project is part of the AFL-CIO Research Department located in Charleston, West Virginia. The department conducts surveys and provides training materials on topics of interest to the membership.

### A. Approach to Metric Change

In order to prepare Appalachian union members for the transition to the metric system, which is occurring in an increasing number of businesses and industries in the United States, the Research Department of the AFL-CIO Appalachian Council has been providing metric education for unions since 1976 in conjunction with the U.S. Office of Education Metric Education Program. During the four-year period, 1976-1980, the Appalachian Council has provided two-day metric seminars for 400 union officers, two-hour metric awareness lectures for 1,000 union members, and labor conference exhibits and displays for more than 8,000 union members. The Council has also responded to hundreds of written requests for materials. Source: Annual Report, Metric Education Program, U.S. Department of Education, 1979.

### B. Present Metric Status

Several thousand workers in the thirteen-state Appalachian region have been trained in the metric system, although relatively few have had occasion to use the knowledge. Pre- and post-tests show that the material is easily learned and that the workers' attitudes became more positive after they have learned the material. It could be concluded that the negative attitudes towards the metric measurement system are a function of lack of knowlege. This is substantiated by comments made by factory workers using the metric system.

### C. Training Approach

The training is provided at the various local AFL-CIO-Sponsored Skill Training Centers upon request. Pre- and post-tests are given to measure what learning has occurred. The trainers are familiar with occupational requirements and tailor each presentation accordingly. Tools appropriate to various trades are used in the presentations so that the trainees experience hands-on measurement activities.

D. Visit Conclusions

Some data relative to preferred training methods and attitudes of trainers were obtained. It appears that the course objectives were met and documented by pre- and post-tests. The courses are geared to the "need to know" approach. The instructor uses the measurement tools appropriate for the occupation of the trainee.

There appeared to be a significant amount of apprehension on the part of the trainees taking the pre-test. This observation is made on the basis that fewer trainees put their names on the pre-tests than on the post-tests. The project team considers this to be indicative of a normal "fear of the unknown".

# ALLIS CHALMERS

West Allis, Wisconsin

Allis Chalmers is a large, diversified manufacturer of machinery and heavy equipment. West Allis' plant is a job shop* that produces large pumps, diesel engines, fossil fuel power plant turbines, and similar products.

## A. Approach to Metric Change

In the early 70's, Allis Chalmers began to develop a corporate-wide metric conversion policy. This was partially due to the involvement of some of their divisions in agricultural products, off-highway machinery and steam turbines. Because of the diversity of the products made by the various divisions of Allis Chalmers and the lack of urgency for adoption of metric measurement in some products, it was difficult to establish a firm corporate policy. However, metric conversion guidelines were published in 1972, followed by a corporate-wide policy in 1974. The current Allis Chalmers corporate policy allows each individual, division, or plant to establish its own commitment to metric measurement. Allis Chalmers decided to adopt the metric measurement system on specific projects that produce a Swiss-designed marine diesel engine and a German-designed turbine. Because the West Allis plant operates primarily as a job shop, the approach to metric measurement within this plant has focused exclusively on these two projects. Thus, within this individual plant, both metric projects and inch projects continue to be worked on, and this dual measurement usage will continue for some time.

## B. Present Metric Status

Fourteen metric turbines made to metric design have been produced for fossil fuel and nuclear power plants in several states. The designs for these turbines were licensed from Kraftwerk Union Aktiengesellschaft, Mulheim, Germany. These turbines have been installed in several states throughout the U.S. over the past nine years. In at least one instance, in Louisiana, these turbines have been overhauled by U.S. firms; in this case, Brown and Root from Texas.

In addition, Allis Chalmers is currently building three larger diesel engines for Avondale Shipyard, Inc., New Orleans, Louisiana. This particular product is being produced under a manufacturing agreement with Sulzer in Switzerland and is designed in metric measurement.

* A job shop manufactures or repairs specialized products in small quantities with little or no automation to meet customer specifications.

## C. Approach to Tools

The field site training staff helped the project team to obtain a clear picture of the workers' views on metric conversion by arranging a meeting with the U.A.W. Local 248. The metric tools required to work on the Allis Chalmers metric projects are provided by the company. In addition, many machinists are gradually purchasing their own metric tools. According to the machinists, they do this because they are not always satisfied with the condition of the company tools, which are shared by many workers, and they state that personal tools receive better care. In any case, a machinist at Allis Chalmers could spend a maximum of $1,000 for metric tools if he chose to purchase them. The UAW Local has arranged to get lower tool prices through volume discounts for workers who are purchasing personal metric tools.

## D. Training Approach

Training aids were developed and made available to employees as early as 1967. In the beginning of the implementation of metric into the manufacturing processes, classes were conducted during working hours on metric metrollogy. Machines were fitted with conversion read-outs and employees frequently conversed with engineering and shop management personnel on problems arising from metric and the use of first angle projection on drawings.

In the early stages of the metric projects, according to employees, Allis Chalmers did not fully meet the metric training needs of the employees. During this period the employees assigned to these projects became somewhat concerned about their lack of understanding of the metric system. As an example, they stated that if a conversion error was made on a drawing, then the machinist, who had little or no knowledge of metric measurement, could be held responsible for any machining errors due to the drawing error. As a result of this concern, the local union arranged for a metric training program to be provided by an independent consultant. Local 248 of the United Auto Workers, which represents labor at West Allis, arranged for metric training at the union's expense. Those sessions were well attended, and were conducted in the evening during the workers' off-hours. Company training was eventually provided for workers including welders, pipe fitters, machinists, assemblers, and secretaries. This training was done on company time.

The training cost to Allis Chalmers was not easily identifiable, but 380 employees were offered training on company time. The UAW program cost $3,750 to deliver a 12 hour course (2 hours per session - 6 sessions) to 250 workers. There were no development costs since the program was delivered off the shelf by a metric consultant. Although there is some disagreement on the relative success of the West Allis approach to metric training, all agree that the level of metric knowledge of the workers is now adequate. The union attributes workers' initial fears and resistance to the initial lack of formal metric training from Allis Chalmers.

## E. Career Issues

Job Mobility - According to management, there is no career mobility problem because all the workers can produce in either measurement system. If there were to be a reduction in work force, skill would be a deciding factor, but knowledge of metric would not. According to the employees, lack of metric knowledge could result in "bumping" and has in some cases caused a decrease in job mobility.

Elderly Workers - Several older workers were interviewed regarding their experience with metric conversion. In each case there was initial resistance and some fear of being unable to learn the new system. The older workers found that they could work in the metric system, but generally found it to be an annoyance. There was an impressive pattern of a philosophical attitude among the older workers that metric was inevitable and that we must teach it in our schools.

## F. Companion Issues

There was not complete agreement between the employees and management on the companion issues.

Safety - Management's perspective is that adequate precautions have been taken. Bolts are color coded for metric and inch, and there has been no conversion relative to the measurement of pressures.

Employees were concerned, however, that even with painted bolts a worker could use the wrong wrench and slip while using it. This could happen when servicing a vehicle whose bolts had become oily and dirty. Other concerns relate to the use of torque wrenches and conversions from foot-pounds to Newton-meters. There was also concern about the ability of the crane operators to accurately estimate the metric load for the customary crane.

Collective Bargaining - According to labor, opposition to metric will not become a bargaining issue because "We want to save our jobs." However, reimbursement for tools or training could become an issue in the future.

## G. Visit Conclusions

The West Allis plant is producing products in both metric and inch measurement units. A relatively discipline-oriented management and the strong work ethic of the employees in the area have contributed to a successful conversion. It appears to the project team that success would have been gained more easily and smoothly if labor had been more involved with the initial training. There is still some fear of and resistance to metric measurement. This fear appears to be based on the workers' perceptions of how metric conversion affects them. Few workers seemed to understand what prompted Allis Chalmers to initiate metric projects.

## ALUMINUM COMPANY OF AMERICA

Alcoa Aluminum is the largest producer of aluminum in the United States.

### A. Approach to Metric Change

The approach to metric change taken by Alcoa is to respond to customers' requirements for either aluminum measurement sensitive or custom engineered products when necessary. Because Alcoa's largest volume of products is measurement sensitive, they have attempted to provide initial support to customers and distributors by publishing preferred metric (SI) sizes for aluminum sheet and plate products, as well as for aluminum extruded shapes, rod and bar products. It is anticipated that preferred metric (SI) sizes for aluminum tubular products, except pipe, aluminum wire and cold finished rod and bar products, will be published within the next few months.

Alcoa, in advocating the hard conversion specified in these publications, does not preclude other sizes from being ordered or from becoming standards for the future.

Custom engineered products, such as extruded shapes, forgings, and castings, are manufactured by a die, tool, or mold, and Alcoa has the capacity to produce these products based on metric drawings. They are actively soliciting European extruded shape business designed in metric.

Alcoa is participating in the planning activities of the Aluminum Association and other metal organizations with respect to U.S. standards for metric dimensioned alumimum products.

The actual production and bookkeeping of "metric" orders is done through soft conversion. Orders received in metric (SI) units are converted into inch sizes at the time of the order entry. Mill workers are seldom required to read or comprehend metric specifications.

### B. Present Metric Status

Alcoa presently is receiving some "metric" orders, primarily from the automotive industry, and a somewhat larger number of dual dimensioned orders, primarily from EEC.

The corporate metric staff at Alcoa expressed frustration at the lag and lack of direction in U.S. metric conversion. They also suggested that those companies that have conversion activities underway are experiencing little difficulty and far less cost than anticipated.

## C. Approach to Tools

This aspect of the study does not apply to Alcoa, because there is little actual metric measurement activity on the part of the mill worker.

## D. Training Approach

Training materials and courses are available for management, marketing, sales, operating, and engineering personnel involved in the soft conversion. Although training of mill workers has not begun, the training staff was confident that it could be accomplished smoothly.

## E. Career Issues

A soft metric conversion has no impact on the blue collar worker's job mobility, because there is no need for the worker to be versed in metric measurement.

## F. Companion Issues

The companion issues of safety, collective bargaining, and productivity also do not apply to Alcoa, since Alcoa has used a soft conversion.

## F. Visit Conclusions

The visit was valuable because the study team was able to get an overview of the interdependencies of suppliers and manufacturers; examine the mechanisms and effects of soft conversion; and obtain the views of the corporate staff of this large American manufacturer of a vital raw material.

# AUTOMOTIVE SERVICE CENTERS

A limited number of both union and non-union automotive dealerships were visited to determine the effects of metric change on the automotive service industry. Organizationally, the service centers within a dealership are typically independent from the automotive sales unit, although they may be a subsidiary. Financially, they are often viewed as an independent profit center; and in recent years, the primary focus of the total organization has been on new car sales rather than on providing automotive service. A variety of dealers were visited, including those selling Ford products, General Motors products, and Chrysler products.

## A. Approach to Metric Change

The automotive service centers' approach to metric change is to react to the products manufactured by the automotive industry. Each of the three major automotive manufacturers in the United States (General Motors, Ford, and Chrysler) have taken similar but somewhat varied approaches to metric change. The most common approach has been to incorporate metric change as each new product is designed. A new product may be a carburetor, an engine, a transmission, or even an entirely new vehicle.

The manufacturers provide service manuals to each of the service centers. The manuals outline specific maintenance procedures and diagnostic approaches for each vehicle. Little or no training is offered to individuals at either the dealerships or the service centers, except for "new model" training offered by the manufacturer. Mechanics are expected to provide their own basic tools on the job and to be able to work on the vehicles presented for service, whether they be inch or metric.

## B. Present Metric Status

While many automotive service centers associated with dealerships repair and maintain all makes of cars, they generally have a substantial volume of service in repairing vehicles of the same brand as is sold by the dealership. Consequently, each of the major dealerships has experienced a somewhat different impact as metric components have been introduced into automobiles. However, all of the currently-manufactured automobiles have a mixture of conventionally designed inch size products and newly designed metric components, some of which use metric fasteners and some of which use inch fasteners. While it is true that the automotive manufacturers have attempted to color code the metric fasteners by dyeing them blue or some other color, it is often difficult to determine which of these parts are metric and which ones are inch once they have been coated with grease and oil. The relative percentage of metric components or metric products in an individual car may range from as low as 10% to as high as 90%, depending on the individual model and the year it was manufactured.

## C. Approach to Tools

As the basis of employment, mechanics are generally expected to provide all of the standard hand tools required to dismantle, test, and reassemble the particular automotive parts that they work on, such as engines, drive trains, auto bodies, or suspension systems. The shop generally provides only those special jigs and special tools manufactured for working on a particular component, such as a transmission. In addition, the service center will provide expensive multi-purpose test equipment and other major capital equipment. However, the mechanic is expected to provide all of his own hand tools.

On the surface, this approach to tool ownership appears to be rather simple; however, it is compounded in many ways. As an example, a mechanic is required to have not just one set of standard socket wrenches, but typically a number of different sets. The latter are required because the various bolt configurations and applications are different. Each mechanic typically has the following:

- a standard thin wall socket set
- a standard deep wall socket set for access to highly recessed bolts
- a heavy duty socket set for use with pneumatically driven wrenches that will destroy normal thin wall sockets
- an open end wrench set
- a box end wrench set
- an off-set end wrench set
- others as appropriate.

In short, to be truly effective in their jobs, most mechanics are required to duplicate all of their wrenches in both inch and metric sizes in addition to providing metric sized allen wrenches, feeler gauges, and various other measurement sensitive tools. None of these tool costs are reimbursed by the individual shops. However, those mechanics who choose to can itemize these costs on their income tax statements and obtain an appropriate tax deduction.

## D. Training Approach

Most of the training of automotive mechanics with regard to metric is on an informal basis. They are expected to obtain necessary information by using the manufacturers' manuals and other shop manuals that they normally have available to them. The study team reviewed representative service manuals from each of the three manufacturers to determine the nature of

metric information that they provide. Many of the drawings in these manuals are dual labeled, providing specifications in both metric units and inch units. They dual label such items as torques in Newton-meters and foot-pounds, but they often do not devote much space to defining the basic differences between metric components and customary components.

## E. Career Issues

Mechanics at the dealerships were interviewed in order to get first-hand input on the issues of the elderly worker, productivity, safety, collective bargaining, and job mobility.

Elderly - Working with metric measurement can be a problem in that elderly workers are duplicating many of their tools toward the end of their careers.

Job mobility - The problem of job mobility can surface when a mechanic who works in a specialty, such as front end alignment, must relocate and change jobs; he will not have the metric tools to work as a generalist and may not be able to get another "front end" job. The situation is true for any specialist who has not been accumulating general mechanic shop tools.

## F. Companion Issues

Productivity - Productivity appears to be an issue, because it takes time to identify the metric bolts and obtain the proper tool. This reduction in productivity is not quantifiable.

Safety - One concern voiced frequently was that if the metric bolt is not properly identified, then the wrong wrench may be used. If the wrench slips, the mechanic's hands (or knuckles) could be injured. In addition, incorrect tire pressure and load bearing tolerance for jacks were identified as potential hazards.

Collective Bargaining - In the union service centers, this issue has not been addressed. In the non-union centers, this is not an active issue.

## G. Visit Conclusions

These visits consistently revealed the same facts about the effects of metric conversion on the automotive mechanic; that is, little metric training is offered and self-provided tools are numerous and costly. The only information available to some of the mechanics is found in the service manuals, which are often not available until months after the new model autos are manufactured. The metric tools used by the auto mechanics are purchased by the mechanic himself. Each of these facts contributes to the general conclusion that this group of worker is adversely affected by metric change.

# BOLAND MARINE, DIXIE MARINE, AND GULF BEST ELECTRIC

Boland Marine, Dixie Marine, and Gulf Best Electric are all located in New Orleans, Louisiana and are all involved in the boat repair and marine maintenance industry. The importance of studying these companies is that marine repairers in the U.S. have been increasingly exposed to metric measurement as a result of the repair requirements of the international maritime industry. They are called upon to repair and replace all types of engines, winches, motors and electrical parts on ships that were manufactured all over the world. Boland and Dixie are called upon to repair and replace marine parts that interface with other metric parts. Gulf Best Electric is required to rewind electric motors using available wire to approximate the original metric size. Their business success is dependent not only on quality work, but also on fast turnaround time, because these international transports can cost an average of $17,000 per day to drydock.

## A. Approach to Metric Change

The approach to metric change has been evolutionary over the past 8-10 years in the Marine Repair Industry. This is a function of the decline of U.S. shipbuilding operations and the increase in foreign ship manufacture. The gradual appearance of metric work in the boat repair yards of New Orleans has permitted a smooth transition for management and workers alike.

## B. Present Metric Status

Approximately 30% of the repair work performed by these three companies is metric. The future level of metric repair will most likely increase as foreign shipbuilding continues to expand. An interesting point here is that one of the large U.S. ship builders in New Orleans (Avondale) is currently installing metric diesel engines in three new ships, but they have designed the ships in customary units and interfaced the engines and drives with inch/metric flanges.

## C. Approach to Tools

In each shop, tools are provided to the workers from a crib; however, most workers have their own metric tools. One company manager commented that the workers prefer to use company tools and preserve their own. This company experiences a large amount of tool abuse. The average cost for tools for both electrical workers and machinists is $200 per person.

## D. Training Approach

Other than informal on-the-job instruction given by foremen, no metric training has occurred in the repair shops. This is because the metric measurement system is taught in the trade schools in the area. In each of the three companies, both management and workers agreed that although there are training issues in the industry, metric training is not one of them, even though the workers are required to work in two measurement systems.

## E. Career Issues

Elderly - There was general agreement that the younger workers had an easier time "thinking in both systems". This is because they are taught both systems in school and are working in both systems from the onset of their careers.

Job Mobility - Employees must work in both systems, and their job mobility in the marine industry is impaired if they cannot. However, it was pointed out that the two systems are so much a part of the industry in the Gulf ports that anyone applying for work there would be well aware of that requirement.

## F. Companion Issues

Because the machinists' union was on strike over pay issues, it was not possible to talk to employees who work in the shops. However, several of the foremen who were interviewed had been working in the shops when metric measurement requirements first appeared in the early 70's. The interviews for the secondary issues, therefore, reflect the opinions of former shop workers and do not represent the current workers' views.

Safety - There were no safety problems that could be identified, and no incidents involving injuries could be recalled.

## G. Visit Conclusions

Boland, Dixie, and Gulf Best provided a good basis for contrasting the differences between the sudden introduction of metric measurement in an industry with the evolution of metrics in industry. They are an example of a job shop industry that took on metric work as it appeared. There was very little planning or training. As the U.S. Marine Repair Industry received increasing requests for metric repair, the local trade schools incorporated metrics into the apprentice programs in order to prepare workers for the expected increase in metric work. Metric measurement has become a common element of work in New Orleans marine repair. Metric measurement appears to be a non-issue here.

# CATERPILLAR TRACTOR

Caterpillar Tractor Company is a multi-national manufacturer of earth-moving, construction, and materials-handling machinery, and diesel and gas engines. Caterpillar corporate headquarters are in Peoria, Illinois, and design criteria and engineering standards are essentially controlled from Peoria. Caterpillar products are produced at 15 plants in the United States and 13 plants in Australia, Belgium, Brazil, Canada, France, Mexico, Great Britain, Japan, and India. The desire of Caterpillar management for a common measurement language that could be used throughout the corporation led them to the decision to use metric measurement.

## A. Approach to Metric Change

In November 1971, the Caterpillar Tractor Company made the decision to change all operations to the use of the International System of Units (SI) without necessarily using metric standards. When the decision was made, Caterpillar set some basic policies but did not establish a timetable. Conversion was to proceed as fast as was practical without causing undue disruption of the production process. Each step of the conversion was to be implemented when opportunities arose or when it was practical. The primary goal was to convert to metric measure.

The first step was to make new drawings for a new product in metric units. This involved only a small number of people at each location. Because the engineering drawing is eventually seen by most departments, this gradually required all departments to use metric drawings. Initially, the number of metric drawings was low. Thus, when problems arose, only a small number of drawings were involved, and the delay due to problem-solving was minimal. As more new products were designed, the number of people making metric drawings increased. Currently, all new drawings are made in metric measure.

Existing drawings were not converted to metric except for standard parts which would be used in new metric designs and parts destined for manufacture in new metric plants. Older plants must operate in both systems of measure and produce parts in either inch or metric, depending on the system used on the drawing.

Caterpillar has not completely adopted metric measure. The conversion to metric standards is made only when it will result in design improvement, improve worldwide availability, reduce differences between products manufactured in the U.S. and those produced overseas, or reduce cost. Standards which have been adopted include drill size and steel sheet, plate, and bar sizes. Standards for metric threads and gear modules have not been adopted.

B. Present Status

About 60% of the Caterpillar product line is manufactured in metric units. This involves about 130,000 metric drawings. Since January, 1979, all new drawings are in metric units, regardless of whether they are for a new or an old product. Conversion charts for inch equivalents have not been put on metric drawings since January 1, 1980.

C. Approach to Tools

Caterpillar has always required employees to furnish certain measuring tools when they need them to perform their jobs. Some of these tools include 0-1 and 1-2 inch micrometers, depth gauges, combination squares, 6- and 12-inch scales, and tape measures. When the metric equivalent tool is required, the company issues the metric tool to the employee. The cost to Caterpillar is about $150 per employee; however, most employees only require one or two tools -- a partial set. One year after issue, the tools become the property of the employee. In the new Layfette, Indiana plant, employees will be required to provide their own metric tools. Inch tools will be made available by Caterpillar, as needed.

D. Training Approach

Initially the training lasted as long as four hours. The Caterpillar training group now finds that the average employee requires only one and one-half hours of formal training. This is done on company time. Each plant provides training as required, using corporate training materials. Most training is done on the basis of need and at the time the need occurs. Caterpillar stressed that the time and costs involved in metric training are so little that they are not worth computing. Therefore, no cost figures are available.

E. Companion Issues

The workers who were interviewed stated that the introduction of metric measurement was to a bother to them, because it required that they change their routines. However, they also stated that it was an easier system that should be incorporated in the education of the children of today.

Job mobility - Knowledge of metric measurement is not a mobility or career ladder issue, because training is available at all plants.

F. Companion Issues

Safety - Caterpillar saw a potential for safety problems with tire pressure. For this reason, tire pressure is still specified in the English

system. Workers interviewed at Caterpillar did not see any potential safety issues related to the use of metric measurement.

Collective bargaining - Metric activity is covered in the labor contract at Caterpillar. Because tools and training have been provided by the company from the onset of the use of metric measurement, there have not been collective bargaining issues. Workers interviewed were generally neutral on the subject of metric measurement. They generally related stories of passive resistance, feelings of mild intimidation, and fear of the change. However, they could not identify any particular problems with it.

## G. Visit Conclusions

The visit to the Caterpillar plant in Peoria covered interviews with management, training groups, and shop employees, including machinists, inspectors, and assemblers. The conversion to metric has gone smoothly due to careful planning on the corporate level, efficient dissemination of metric materials and training programs, and good communication between labor and management.

## GARDINER EQUIPMENT OF LA PLATA, INC.

Gardiner Equipment of La Plata, Inc. is a family-owned and operated farm machinery sales and service center serving Southern Maryland. Gardiner sells John Deere tractors and has a staff of five mechanics who service all types of John Deere agricultural equipment. In recent years, because of the need for smaller, more fuel efficient farm tractors, the John Deere Company has been importing and marketing both German and Japanese tractors. These products use all metric parts but with different standards.

### A. Present Metric Status

Gardiner Equipment services a large number of John Deere metric tractors. Twenty five percent of their work currently involves servicing tractors with metric parts.

### B. Approach to Tools

The mechanics can purchase the smaller metric lug and socket wrenches from John Deere for approximately $100, but these tools represent only the bare essentials. Greater expense is incurred to get a complete set of metric tools. The larger wrenches are purchased by Gardiner and are shared by the workers. These John Deere metric wrenches are visibly of inferior design as compared to John Deere inch sized wrenches.

### C. Approach to Training

Metric hardware training has been scarce in the past, but it is becoming more prevalent as the quantity of machines increases. Although assembly manuals are readily available from John Deere, the standards for Japanese and German threads are different, causing confusion in both disassembly and repair.

### D. Career Issues

Elderly - The use of metric tools is no problem for older workers.

Job Mobility - In this small group, it is difficult to identify problems of job mobility related to metric conversion.

## E. Companion Issues

Productivity - According to the mechanics at Gardiner, there is a definite decrease in productivity for assembly and repair of new Japanese and German John Deere metric products. Once the mechanics become familiar with the machine, they are able to increase their speed of assembly and repair. However, they must maintain their familiarity with U.S., German, and Japanese standards. In addition, there are instances when the wrong bolts have been forced into metric threads. Parts damage can be costly and is usually paid for by the company.

Safety - Because it is difficult to recognize metric bolts, inch wrenches are sometimes used. This activity can cause the bolt heads to wear and the wrenches to slip, causing injuries to mechanics' hands.

Collective Bargaining - Gardiner Company is not a union shop.

## F. Visit Conclusions

The Gardiner Company mechanics have been repairing metric tractors for seven years and still experience confusion over the different standards. They are frustrated over this, but do not see any resolution. The cost of tools for the individual is minimal; the cost of decreased productivity, mistakes, and customer dissatisfaction, all borne by the company, is more.

# J.I. CASE - DROTT

Wausaw, Wisconsin

Drott Corporation was a family-owned manufacturer of heavy equipment established in the 1920's in Wausaw, Wisconsin. During the 1970's, the firm was sold to Tenneco, Inc., a multi-industry corporation, and recently was merged into J.I. Case Co., one of the Tenneco Companies. Drott, as part of the construction equipment division within J.I. Case, manufactures excavators, industrial cranes, forestry equipment, and travelift carriers. The firm employs slightly less than 1,000 individuals, and continues to be located in Wausaw, Wisconsin.

## A. Approach to Metric Change

In the mid 1970's, Drott entered into an agreement with Poclain, a French manufacturer of excavators. Initially, this agreement only addressed the cross licensing of Drott equipment and Poclain excavators in both countries. Following this initial agreement, it was decided that Drott would manufacture the Poclain excavator in Wausaw. This decision was the initial impetus for Drott to address the issue of metric training. The Poclain excavator was designed in metric units and was to be manufactured in Wausaw from the same drawings as were used in France. Drott began manufacturing the Poclain excavator in 1978. In addition, it was decided at this time that all new Drott designs would be metric and that all employees would eventually require some metric training.

## B. Present Metric Status

Presently, the efforts to integrate Drott into the J.I. Case Construction Division are resulting in the establishment of corporate-wide engineering standards throughout J.I. Case. This effort will most likely lead to Drott being influenced by the J.I. Case metric conversion policies; however, this was not specifically addressed during our study. Approximately 15-20% of Drott products are designed and produced in metric at this time. These products are primarily in two product lines, the Poclain excavators and the travelift carriers.

## C. Approach to Tools

Drott does not provide individual tools to employees. Blue collar workers who use metric units include template makers, tool makers, inspectors, hydraulic repairers, and fabrication inspectors. Workers volunteered to work on the Poclain project, knowing they would need to spend an average of $109 each for tools. All quality control gauges and tools are supplied by the company. Drott spent $37,000 for expendable metric tools (such as drills and taps) and $5,000 for quality control tools. These tool costs

are only associated with the current metric products, and additional tool costs would be incurred if all products were completely in metric.

## D. Training Approach

In preparation for production of the Poclain excavators, Drott requested that North Central Technical Institute (NCTI) provide training to employees who had volunteered to work on the Poclain project. The training program for Drott was developed by NCTI. NCTI obtained a grant from the State of Wisconsin which funded 70% of the $9,100 estimated development cost. NCTI developed a 13-part training program to meet the training needs of management, administrative support staff, and blue collar workers. The course content was modular, and only those portions necessary to any particular worker's tasks were offered. No metric to inch or inch to metric conversion was taught. Training was accomplished at the factory, on company time. A total of 371 people were trained by NCTI.

The cost for developing the training materials was $13,500, excluding approximately 10 days of NCTI management time. The actual total cost of the training delivery was not available. However, NCTI was paid $3-$10 for tuition per person. Participation costs were estimated for approximately 100 engineering department personnel. An approximate cost of $15,000 for these 100 employees is based on the average salaries and actual total hours spent in class by employees. Note, however, that this estimate is only for 100 people -- not for the entire 371-person workforce that was actually trained. These costs also do not include lost production time, although the classes were conducted at the plant on company time, and the workers were paid for the time they spent in class during regular working hours. (If the class ran later than the worker's shift, the individual was not paid overtime.) Although the cost information on this project was limited, the visit to NCTI provided excellent data on what is involved in developing a metric course that not only meets the needs of all levels of company employees, but is also transferable to another company.

## E. Career Issues

Elderly Workers - Two elderly (over 55) tool and die makers were interviewed. They were frank about their initial skepticism, but said they learned the metric units quickly. They saw no decrease in their own productivity. Both of these workers volunteered that the metric system was, for them, better and more accurate.

Job mobility - Lack of metric knowledge would not affect a worker's chances for a change in job status. Each worker is offered metric training. However, since the worker is expected to provide his own tools up to one inch wrenches, a new metric job might cause him some tool costs.

## F. Companion Issues

Safety - There was no documented incidence of an unsafe situation caused by use of the metric system.

Collective Bargaining - Drott is not a union shop.

## G. Visit Conclusions

The introduction to metric measurement was done after careful planning and with attention to the employees' individual learning abilities and concerns. This is reflected in the use of professional vocational educators. Individual involvement in the project was voluntary, but the employees who took part were expected to purchase some basic tools.

After interviewing Drott management, NCTI trainers, and several Drott employees, it appears that the metric change went smoothly.

## JOHN DEERE

John Deere manufactures agricultural and construction equipment both in the United States and abroad. Because of Deere & Company's worldwide involvement, the company perceived that it would be advantageous to adopt SI metric units and thus standardize the measurement of components and raw materials. Accordingly, the use of SI metric units was adopted in 1973.

### A. Approach to Metric Change

A Standardization Handbook was issued on corporate standards. This lists preferred metric sizes to be used by design engineers. All new machine tools are purchased with metric or inch-metric capability so that the new designs can be produced in metric.

### B. Present Metric Status

Almost all John Deere plants in the U.S. and Canada are designing in metric units. Inch units are used only where the part interfaces with an old part. John Deere expects to have full metric capability by 1985.

### C. Approach to Tools

John Deere factories provide special metric tools as needed. John Deere does not supply metric or inch tools to new hires except where specialized tools are required. Employees can check metric or inch tools from the crib if they do not have their own tools.

### D. Training Approach

Training materials are provided by the plants and by the Corporate Metric Conversion Committee. Each plant decides how to go about the implementation of metric training. Generally, the training is geared to the "need to know" concept of instruction. Deere & Company finds that little training is actually needed. Training costs are difficult to measure, because training is done differently in each plant. The amount of classroom time spent in learning metric measurement is very small.

### E. Career Issues

Job mobility - Job mobility is not an issue because metric training, if needed, is readily available at each plant.

Elderly - Initially some of the older workers expressed skepticism; but according to management, there is no measurable difference between the ability of younger and older workers to use metric measurement in their work.

F. Visit Conclusions

It appears that metric conversion was introduced smoothly at John Deere. Because there are no blue collar workers at the Corporate Offices, it was not possible to talk to them. John Deere's approach to conversion seemed well structured and consisted of:

- metric dimensions for new designs
- standardized designs
- procurement of machines with metric capability
- teaching metric to employees
- evaluating the training program.

# LOUISIANA OFF-SHORE OIL PORT

Louisiana Off-Shore Oil Port (LOOP) is a consortium of five U.S. oil companies, including Marathon Pipe Line Company, Texaco Inc., Shell Oil Company, Ashland Oil, and Murphy Oil Corporation. In August, 1977, LOOP Inc. announced that it would proceed with the construction of a deepwater port. The port consists of a marine terminal, connecting offshore and onshore pipelines, and a storage terminal. Several pipelines will receive crude oil from the storage terminal and move the crude to local refineries or to pipelines which link Louisiana with Midwestern and some Eastern refineries. There are several reasons for LOOP to use the metric system. The main reason was the belief that the U.S. will go entirely metric in this decade. In addition, some of the oil to be received will be measured in cubic meters.

## A. Approach to Metric Change

The approach taken by LOOP was to use only metric measurements on their drawings and specifications for the oil handling equipment. Operational temperature, weights, volumes, and pressures would be in metric only. There would be no soft conversion or dual readout on dials. While the structure was built with mostly customary sized components, some suppliers provided parts and materials (pumps, valves, and meters) in metric. All operations instructions are in metric, and the computer that controls the operation reports data only in metric.

## B. Present Metric Status

LOOP is expecting its first shipment of crude oil about May 1st. The oil may be measured by the exporter in barrels, and this may be converted into tons by the shipper. However, LOOP will off-load, transport, and store it in cubic meters. Originally, it was expected that LOOP customers would take delivery from the pipeline in cubic meters. However, since there has been an unexpected lull in U.S. metric activity, these customers are now requiring delivery in U.S. barrels. The U.S. Customs Service and the Louisiana state tax agencies are also requiring that LOOP do all official reporting in barrels. LOOP will comply with these requests, but there are some unresolved differences, including a disparity in conversion tables and standards for temperature compensation.

## C. Approach to Tools

All tools for pump, valve, and meter maintenance are furnished by LOOP. Traditionally the petroleum industry supplies worker tools. No tools are needed for the operational personnel.

## D. Training Approach

Training at LOOP is a major activity because all the employees are new and come from a variety of sectors of the petroleum industry. Trainees include secretaries, clerks, maintenance technicians, cargo transfer aides, meter operators, and pump persons. There is a concentrated learning atmosphere at LOOP, which is a function of the start up of this major oil receiving port. The trainees receive the training manual for the metric course in advance. The course is two hours in length and covers basic information about temperature, volume, and pressure in the metric system. The course is a prerequisite for the operational courses in pumps, valves, and LOOP operation. The course has been well received.

## E. Career Issues

Elderly workers - They have been as successful as all other employees in learning metric measurement.

Job mobility - Because the operation is new and all personnel are being trained in the use of metric measurement, this will not be an issue. There are plans for continuous training programs for new employees.

## F. Companion Issues

Because the employees who are being trained in metric were in orientation programs, it was not convenient to meet with any of them. The views on the secondary issues are those of management and training personnel.

Safety - Safety is an extremely important issue to LOOP because of the potential environmental impact of a leak. The port is totally automated, so any operational errors are corrected by emergency mechanisms. This line surveillance program detects errors and leaks, and alerts the computer operator. This system assures the integrity of the oil pipes from the ship to the customer.

Collective Bargaining - This is not an issue because LOOP employees are not represented by organized labor.

## G. Visit Conclusions

The Louisiana Off-Shore Oil Port is committed to the operational use of metric measurement. This has proved to be costly to some suppliers, because they had difficulty meeting metric requirements during construction. Federal and state taxes have become metric usage issues as well. It appears that the smallest problem in this metric project has been introducing metric to the employees. There is an air of enthusiasm for using the new measurement system, as well as a sense of frustration over the bureaucratic obstacles mentioned in paragraph B.

# MAYER, ROTHKOPF INDUSTRIES

Mayer, Rothkopf is a German-based manufacturer of circular knitting machines with a plant located in Orangeburg, South Carolina. All of the machinists are American.

## A. Approach to Metric Change

Because Mayer, Rothkopf is a German company, it has always manufactured its product using metric measurement. Recently, however, they purchased the design of an American knitting machine that was designed using customary measurements and inch standards. For this product they had all 4,000 drawings converted to metric at a cost of $5,000. This was necessary because all but one of their machine tools is set up for metric use. (For that single inch-based machine, there is a machinist who converts from metric to customary units before making the part specified. He was interviewed and voiced no problems. In fact, he was clearly proud of being assigned to the machine, although he prefers the metric system.)

## B. Approach to Tools

All tools are supplied by the company. Employees who were interviewed find this to be satisfactory; none have purchased their own tools.

## C. Approach to Training

Mayer, Rothkopf requires that potential employees attend the local technical institute for metric training. There are other job opportunities for machinists in Orangeburg, but Mayer, Rothkopf has no problem recruiting, even with this pre-employment training requirement. The turnover rate is 2%. The total class time for metric training is 10 hours, and over 700 employees have taken the course.

## D. Career Issues

Elderly - A foreman who was interviewed felt that older workers were more resistant to learning the metric system, but that they had no problem with it once they learned it.

Job Mobility - Mayer, Rothkopf would train a good employee without hesitation if the employee wanted to move up and into a measurement sensitive job. Lack of knowledge about the metric system would not hold back an employee.

E. Companion Issues

Safety - Although there was no safety issue identified by employees or management, they agreed that in using measurements that are not commonly used by the workers (such as weight), a person could possibly face a safety issue if weight limits (on cranes, for example) were specified only in metric. Management also suggested that the metric safety issues would appear more in the chemical processing industries.

Collective Bargaining - Mayer, Rothkopf employees are not represented by organized labor.

F. Visit Conclusions

The visit to Mayer, Rothkopf was enlightening because there was ample opportunity to talk with rural American workers who work in a foreign-owned and managed firm. There are language differences, as well as a different measurement system. The workers were open and frank about the situation. They were obviously pleased with their work and with their association with Mayer, Rothkopf and the metric system. There were no references to fear of learning the new measurement system. It could be assumed that the workers' attitudes were different because they chose to work with a company using the metric system and, therefore, made the metric decision for themselves.

# REGAL BELOIT CORPORATION

Regal Beloit is a manufacturer of specialty tools and has facilities throughout the United States. Regal Beloit manufactures cutting tools, gauges, thread gauges, and similar items for a wide range of manufacturers.

## A. Approach to Metric Change

As a specialty tool manufacturer, Regal Beloit viewed the national interest in metric measurement in the late 1960's as an opportunity. Thus, Regal Beloit began to make metric taps and dies as speciality items available upon request. As one of the early providers of metric cutting tools, taps, and dies, Regal Beloit's business in this area has continued to expand; approximately 32% of their sales are now in metric products.

## B Present Status

Regal Beloit operates primarily as a job shop and is capable of producing metric cutting tools and other components to ISO standards or U.S. standards in any of these facilities. At the present time, approximately 32% of company-wide sales are in metric products. Pricing of these products was recently reduced to reflect the increased volume of business in metric products. Prior to this time, pricing of metric products had been higher, reflecting the position that they were premium or speciality products.

## C. Approach to Tools

Metric tools have been provided to all of the workers currently employed by Regal Beloit. Because of the increase in metric activity within the corporation, new employees are now expected to provide their own metric tools when they join the company.

## D. Approach to Training

In 1970, Regal Beloit developed and initiated an in-house training program to assist its workers in producing metric products. These training programs led to a rather informal approach consisting of two or three hours of work-oriented sessions addressing specific measurement units used on the job. At an average cost of $10.40 per hour (including fringe) and approximately three hours per person, the training cost for an individual on company time is a little over $31.

## E. Career Issues

Elderly - Elderly workers have no difficulty in learning and using the metric measurement system after receiving on-the-job training.

## F. Companion Issues

Collective Bargaining - This is not an issue, because Regal Beloit does not have labor representation in its plants.

Safety - Regal Beloit has not identified or observed any incidences of safety problems related to metric change.

## G. Visit Conclusions

Regal Beloit has been working with metric measurement for approximately 10 years in most of its U.S. plants. Their experience seems to indicate little or no difficulty in providing adequate metric training to employees.

# ROBERT BOSCH DIESEL INJECTION

Robert Bosch is a German-based firm and is one of the world's leading manufacturers of ignition, fuel injection, and lighting equipment for cars. One of their largest plants is located in Charleston, South Carolina.

## A. Approach to Metric Change

Because Bosch is a multi-national German manufacturer, its products have always been in metric. This site visit allowed us to examine the attitudes of, and effects on, workers who were employed by a manufacturer that was already working exclusively in metric. In other visits, the process of metric conversion was introduced to workers after they were employed.

## B. Approach to Tools

Bosch supplies all tools for employees and states that that practice is traditional with German companies. Commonly-used tools such as Vernier calipers and micrometers are issued to each employee, and all other tools are available from the crib.

## C. Approach to Training

Although Bosch has been located in the U.S. for many years, it has only been in the last few years that formal training has been introduced. An ambitious training project is now underway that includes an apprenticeship program, as well as a menu of Bosch-authored metal manufacturing courses offered at Trident Technical College. One of the courses is Introduction to Metric Measurement. Bosch's hiring practices allow a plant to hire as many as 10 new employees at one time. Bosch recruits with the requirement that the potential employee will attend required courses at Trident before being hired. Employees who were working before the Trident program was initiated are encouraged to attend night courses at Trident. The metric course at Trident requires five hours of class time.

Before the metric training class was available, Bosch had a problem with employees misunderstanding the metric system. Now there are no problems and morale is good, according to both management and the employees who were interviewed. "Training changed the attitude of the employees."

D. Career Issues

Elderly - The older workers had no difficulty in learning the system.

Job Mobility - Job mobility could be a problem if the employee left Bosch and went to work for a firm using the inch measurement system. However, the problem would not be serious because Americans learn the inch system in school.

E. Companion Issues

Safety - There are no safety issues at Bosch and no history of accidents associated with metric measurement.

Productivity - According to employees, the use of the metric system increases their productivity because it is a simpler system.

Collective Bargaining - Bosch employees are not represented by organized labor.

F. Visit Conclusions

The visit to Bosch was especially valuable because the study team was able to view a company-run apprenticeship program which was totally metric. In addition, there were numerous opportunities to talk with apprentices about their training experience. These students are learning their trade from foreign trainers who have introduced a new measurement system. In each case, it was found that the apprentices were satisfied with the program and preferred the metric system.

## SIGNODE CORPORATION

Signode Corporation, Glenview, Illinois, is the worldwide leader in the manufacture and sale of steel and non-metallic strap, as well as the equipment used in its application.

### A. Approach to Metric Change

Signode performed an analysis of the benefits and effects of hard metric conversion in the early 1970's. This was done because the international market required foreign manufacture of the Signode packaging equipment. This international involvement of an American-designed inch product resulted in modifications being designed in metric. In order to gain uniformity and in light of the possible conversion in the United States, it was decided that all newly designed Signode packaging equipment would be designed and produced in metric. All new designs since 1978 are metric.

### B. Present Metric Status

15% of Signode products are now designed and produced in metric. All departments are educated in and are using metric drawings to some extent. One group that is not using any metric measurement is the tool room, where tools are produced to be used for internal consumption within the factory. Since these tools do not leave the plant, their being made by using metric measurement is not critical.

### C. Approach to Tools

Since 1976, Signode has spent $105,000 on gauges, dual readout equipment, shadow graph optical comparators, etc. This is necessary because Signode continues to manufacture in both the metric and customary measurement systems. In addition, there is the continuous expense of dual inventory of disposable tools. Metric tools are supplied to workers on a sign-out basis. This seems acceptable to workers.

### D. Training Approach

314 employees, including machine operators, design engineers, assemblers, and clerical staff, have been trained to use the metric system. The course is offered by the training department on company time in five formal sessions, for a total of 10 hours. Under no circumstances are foremen advised of workers' metric training test results.

Training cost:

Development costs were estimated at $5,000. This included the cost of authoring and initial clerical costs.

Training delivery costs included:

$12,000 - trainers' time based on the number of sessions held between 1976-1980.

$2,850 - travel between Kentucky factory and Illinois factory

$470 - materials

$94,500 in salaries paid to 314 workers for 10 hours at $30/hour (salary and fringe)

## E. Career Issues

Elderly - At the onset of the metric change process, there were some doubts voiced by elderly workers. There was, however, no resistance. Older workers who have been trained and are using metric measurement have not demonstrated any disability in this area.

Job mobility - Because the training program is available, knowledge of the metric system is not a factor in job mobility. However, when an employee is considered for a merit pay increase, the ability to work in both systems is considered.

## F. Companion Issues

Safety - There are no documented safety incidences regarding metric conversion.

Collective Bargaining - This is not a consideration because Signode plants generally are not union shops.

## G. Visit Conclusions

The training department designed the instructional materials and carefully planned with management the provision of instruction to all workers involved. All of the workers were concerned about failing tests related to training programs for new tools. The workers' concerns about testing and its potential impact on their job security were handled by Signode's ensuring the confidentiality of all testing. Consideration for the expense to the employee in terms of time and tools resulted in the decision to provide the training on company time and the tools on a sign-out basis. The workers who were interviewed voiced no problems with the metric activity at Signode.

## SUN PETROLEUM PRODUCTS COMPANY

The Sun Petroleum Products Company in Toledo, Ohio, is a division of the Sun Oil Company of Pennsylvania. Sun produces a variety of petroleum-based products throughout the United States.

### A. Approach to Metric Change

The Sun Company initiated a metric planning project in 1975, under the assumption that a major transition to metric change was being undertaken throughout the United States. Sun established refinery committees that developed a metric change plan. The decision was made to consider metric units only for new plants as they were designed or as they became operational. Since that time, three new refinery units have become operational. Two of these are in Toledo and one is in Canada.

### B. Present Metric Status

Sun has reacted to the recent lack of enthusiasum for metric change in the United States with some concern. As a corporation, they are not sure how metric change is evolving in the United States, and they expressed some concern during the interviews that this lack of direction has led to confusion in various industrial sectors, including their own. At the Toledo division, two refining units became operational in recent years, and they make some use of metric units. Few new plants have been added in other locations in recent years, and thus, the level of metric activity has been limited to just the two Toledo plants and the one Canadian plant.

### C. Approach to Tools

Since the use of metric measurement in these units is somewhat limited, only a few components are actually designed in rational metric sizes. For these components, Sun provides metric tools when they are required during the normal maintenance or operation of the unit. This is the only experience that Sun has had with regard to metric tools at this plant.

### D. Training Approach

The primary focus of the Sun Petroleum training program was on approximately 50 process operators who spent about 10 hours on company time learning the metric measurement system. These individuals then incorporated metric measurement, to the extent possible, in new refinery projects. Insofar as hardware goes, some pumps were designed in metric sizes. The calibrations for instrument meters are done using conventional measurement units. Sun has not experienced any difficulty with this approach.

The computer programs which process data for these two refinery units use metric data, and the programmers have had to perform some conversion activity for the computer programs. Insofar as the operations people are concerned, most operational decisions are made by watching trends on dials or determining when a particular meter has exceeded a limit which is marked on the dial. Thus, in day-to-day operations, people are rarely actually reading numbers off of these dials. So, the change from customary units to metric units has had little impact on the operations of these units.

## E. Companion Issues

Because of the limited experience Sun has had in dealing with metric change, there was not much material available dealing with the secondary issues. Sun does not view experience with metric measurement as a particularly important element in safety, nor has it become an issue in labor negotiations.

## F. Visit Conclusions

The experience of Sun Petroleum Products Division with metric refining units did not raise any substantial tool or training issues. However, it is clear that the Sun Company is not pursuing its metric change with the original enthusiasm of three to four years ago. Thus, it may well be that the experience of the Petroleum Products Division had been less significant because of this reduced emphasis on metric change.

# U.S. STEEL

U.S. Steel is one of the larger manufacturers of steel in the United States. They also operate major divisions that are elements of other industries, such as the U.S. Steel Chemicals Division.

## A. Approach to Metric Change

The approach to metric change taken by U.S. Steel is to meet their customers' requirements as efficiently as possible. Because U.S. Steel furnishes many raw products that are used in measurement sensitive industries, they have attempted to provide conversion support to customers by publishing a catalogue of standard U.S.S. metric dimensions based on ANSI-preferred sizes for flat, round, square, and hexagon metal products. U.S.S. considers this publication as a tool to be used in metal industry planning to convert to metric.

The actual production of metric-sized steel products is done through soft conversion. Orders that are received that use the published metric sizes are converted by computer into equivalent inches. The order is reconverted into metric when it is packaged for shipment if the customer requires invoicing in metric units. At no time are the mill workers required to read or comprehend metric specifications.

## B. Present Metric Status

The corporate staff at U.S. Steel expressed frustration at the lag in U.S. metric conversion. They consider it costly to have to carry a large variety of both metric and inch sizes for many years due to the existence of two measurement systems. Eight percent of their orders are now in metric. They are aware that there could be far more metric orders, but the smaller companies that would order in metric are dealing with steel service centers. The service centers, which operate as steel distributors, do not presently stock metric sizes and, thus, small orders in metric units are discouraged. The steel service center customers must accept available stock.

## C. Approach to Tools

This aspect of the study does not apply to U.S. Steel because there is no actual metric measurement activity on the part of the mill worker.

D. Training Approach

Training materials and courses are available to employees who are involved in the soft conversion. Blue collar workers are not actually trained, but they are made aware of the eventual use of metric measurement through awareness posters. U.S. Steel purchased a commercially available metric training package and supplemented it with internally created materials.

E. Career Issues

Soft metric conversion has no impact on career issues, because there is no need for the worker to have specialized training or tools.

F. Companion Issues

These issues also do not apply to U.S. Steel. Safety, collective bargaining, job mobility, and the effect of conversion on the older worker are of no consequence, since U.S. Steel has used a soft conversion.

G. Visit Conclusions

The visit was valuable because the study team was able to get an overview of the interdependencies of suppliers and manufacturers; examine the mechanisms and effects of soft conversion; and obtain the views of the corporate staff of this large American manufacturer of a vital raw material.